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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL 2ND, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 8th day of February, 1917. 5942
C. J. STEWART, Public Trustee,
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LITERATURE.

A Handbook of Briquetting. By Professor G. FRANKE, Berlin. Translated by FRED. C. A. H. LANTSBERRY, M.Sc., Head of the Birmingham Small Arms Company's Laboratory. In two volumes. Vol. I. *The Briquetting of Coals, Brown Coals, and other Fuels.* London: Chas. Griffin and Co., Limited. [Price 30s. net.]

THIS book has been unfortunate: apparently it was issued in Germany some six or seven years ago, but though translation rights were secured before the war, it is only recently that it makes a tardy appearance in an English dress. A fire at the printers in which the whole of the edition, together with the type and blocks, was destroyed, contributed to postpone its publication, though the enterprise of the firm reduced the effects of this mischance to a minimum. The delay, from whatever cause, is of the less consequence, since the treatise refers to the conduct of an industry little practised in this country, and notwithstanding the translator's urgent recommendation to turn to account the economical resources of the country, the process is hardly capable of extension at a time when new machinery is unprocurable and labour is scarce. The main inconvenience or disappointment arises from the belated character of the statistical portion. Little or no information is provided subsequent to 1907, and this omission makes it impossible to trace the rapid development effected by German energy, exhibited as it has been both in the conduct of trade and improved technical methods of manufacture. This volume deals only with coal briquetting, and another is promised giving a description of the application of the method to ores, metallurgical products, and metal swarf, as also of "agglomeration," a process by which materials are baked or fritted together into more or less shapeless masses without pressure.

Owing to the advances made in the methods of economical production, considerable ingenuity has been displayed in the treatment of materials adapted to briquetting, and the second volume will appeal probably more forcibly to the English public than the present instalment, which sings a little too stridently the merits of German workshop practice. The author invites us a little too openly to admire the results of German initiative and determination; he conducts us through so many manufactories where similar processes are repeated with slight variation of detail, that the study of perfection tires, and the comprehensiveness of the survey induces weariness rather than excites admiration. In the present strained relations between the nations, German self-esteem would probably resent these remarks as savouring of jealousy, inspired by the knowledge that the German briquetting industry practically doubled within six years, and ten years ago boasted an output of 16,500,000 tons, while at the same date our annual output was only a modest 1,500,000. This poverty of production is, however, easily explained. Our extravagance may be blameworthy, but we are not under the same necessity to husband our resources. Possessed of an unlimited supply of excellent hard coal, we have not been compelled to produce a comparatively expensive article, that would very imperfectly compete with the crude coal at the pit's mouth. In only one district, that of South Wales, has any effort been made to develop an oversea commerce. The translator hints that we have neglected an opportunity, and probably hopes that a wider diffusion of information will rouse us from our lethargy. Doubtless we have been too careless of the wealth that lies latent in goaf and slack. "Since in our own country," he says, "the supply of fuel is of the highest quality, it should be the more profitable to undertake the briquetting of fine coals"; but this statement may be doubted. German prudence and economy have shown very conclusively that it is more profitable to apply the process of briquetting to the brown coals rather than to the higher class. Under favourable circumstances Professor Franke shows that the profit on a ton of hard briquetted coal is 1 mark, but on the brown coal, though the briquettes are sold at a lower price, the profit is 3½ marks per ton. The better result may be attributed to many causes, not the least important of which is the greater attention that has been devoted to the exploiting of the brown coal industry, as shown by the fact that more than 12,000,000 tons of the lower-class briquettes were produced, in 1907, against 4,000,000 tons of the more expensive coal.

The object of briquetting is to give a commercial value to coal products that would not otherwise find a market, but inasmuch as coals differ materially in their composition, some being dry and hard, others soft and earthy lignites, containing much moisture, methods of treatment have to be arranged to meet particular requirements. The difference in manufacture is sufficiently wide to require the division of the treatise into two portions. In the one case, briquetting can only be effected by the addition of a binding material, such as pitch, to give the necessary firmness and cohesion. In the other, simple pressure without adhesive material is sufficient to make the coal fragments adhere, but having a much higher water content, prolonged drying operations are necessary. In neither case are these operations many or complicated, but wherever material has to be handled in large masses, the several processes must be arranged to reduce the expenses of manufacture to a minimum. At the risk of being tedious Professor Franke enters into the minutest details, demonstrating every possibility to economise labour, and making careful comparisons between the mechanical efficiency of the devices that experience and ingenuity have introduced. This struggle after completeness has made the book of unusual length.

Whatever the nature of the raw material, the process of briquetting is designed to give a degree of cohesion to the finished product that shall be equal to that of good coal, in order to prevent loss by attrition and crumbling during transport. The calorific value as determined by evaporative power must not fall below that of coal. The briquette must not contain more than 5 per cent. of water, nor be capable of absorbing moisture, and the ash should not exceed 10 per cent. If the briquette is required for domestic heating, in addition, it must not soil the hands, must be odourless, easy to ignite, and make little soot or smoke. Finally, it must be produced of that weight and form which is best adapted for the purpose for which it is intended, and the special circumstances under which it is to be transported, stored and fired. We gather that the German public, the railway companies and the mercantile marine are sufficiently exacting in their demands, and that the briquette manufacturers have to fulfil their contracts with precision.

The degree of success attained in the manufacture of briquettes, respecting the more important qualities of cohesion and calorific value, can be shown in a tabular form, elaborate testing experiments having been made on a large scale. Only the mean values are given, and it must be admitted that the deviations on either side of the average are rather wide. No doubt the coal samples differ very considerably, and in the various tests these have not been taken from the same mine, though in the same district and of the same quality:—

District and Kind of Coal.	Average Degree of Cohesion. Percentages.	Heating Value in Calories.	Kg. of Water at 0 deg. C. Evaporated by 1 Kg.
Upper Silesia	81.11	6,400	—
Lower Rhenish Westphalia	52.71	7,820	8.196
Gas coals	73.48	—	7.512
Fat coals	46.37	7,823	8.444
Aachen	60.23	—	8.643
England and Scotland ..	58.05	6,870	7.980
Briquettes (Westphalia)	53.31	7,407	8.635
Briquettes (Westphalia)	61.49	7,816	8.383 (Aachen)

This table shows that the briquettes from the Lower Rhenish Westphalia district, the main seat of the industry, possess a somewhat higher degree of cohesion than the average of the natural coals, and that they have a decided superiority over the fat coals which furnish a considerable portion of the supply. The number of calories per kilogramme is very satisfactory, and when judged by the evaporative power the briquette has an equally good record, though in this last test much must depend upon the construction of the boiler plant and the method of conducting the experiments. No coal quoted has practically a higher evaporative power than the Lower Westphalian briquette (8.635 kg.). The gas coals fall considerably below this standard. This is a striking testimonial in favour of briquetting, and shows how successfully the Germans have treated a waste product that cumbered the coalfields.

Naturally only small coal and waste are used for briquetting, the particles varying in size from a powder to grains about 10 mm. in length, and smithy or hard coals are found best adapted for the purpose. The proportion of fine dust to the larger grains is of no great consequence, but a uniform distribution of some dust among the coarser grains is not only of advantage, but absolutely essential to the formation of dense, strong, briquettes. Where this dust is present in large quantities the amount of binding material has to be increased, and the cost of this ingredient may make the manufacture unremunerative. This bonding agent fixes a limit to the utilisation of the waste material. Briquetting is only possible by the admixture of the coal with pitch or other binder, and not the least important problem in the progress of the industry is to find the most economical way in which the due cohesion may be effected. In a factory designed to produce 30,000 tons of briquettes per annum the cost of a ton will average 12.17 marks, and the raw material will consist of 93 per cent. of coal waste at 8.50 marks per ton and 7 per cent. of pitch binder at about 40 marks. To a great extent the whole possibility of the industry as a profit-making concern turns on the price of pitch. If the price is low—a fall of 5 marks per ton will increase the profit by 0.35 marks per ton—or if the quantity of pitch can be reduced from 7 per cent. to 6½ per cent., a slightly less but a sufficient profit can be earned, and the business is remunerative in ordinary times. But in any case the margin of profit is narrow, even where the output is much increased and the expenses can be distributed more favourably. Cheaper binders have been tried, but without great success, and in any case all the operations have to be conducted as economically as possible. Labour-saving devices operated by automatic contrivances have to be everywhere employed, waste heat has to be utilised, frugality has to be studied, and the interest of the book under notice consists largely in following the ingenuity displayed in the several processes through which the raw material has to pass.

These are few and simple. The fine coal is brought from the dressing plant with which the factory is usually connected. Further crushing may be necessary, but this is generally avoided, and if the coals have been washed they need drying. The binding material, which may be lime, resin, hydraulic gypsum, &c., though no reliable substitute for coal-tar pitch has been found, is broken up, pulverised, and added to the fine coal in definite proportions. The ingredients are well mixed together, and if drying is necessary the operation is carried on in heated ovens, in which the mass is warmed up and the excess moisture removed by evaporation. A thorough kneading of the mixture is necessary, and this is facilitated by the introduction of highly superheated steam, which ensures the required plasticity to the whole mass. Finally, the whole is compressed under a pressure of from 200 to 300 atmospheres into the required form of briquettes, and the product is ready for loading and shipment. This sounds very simple, but when 100 tons a day, and in some factories very much more, have to be manipulated, there is ample scope for varied treatment in order to save labour and energy if the most economical methods are to be secured. Professor Franke describes the details very minutely, grows enthusiastic over the automatic machinery, and exhibits the working arrangements of several firms, apparently inviting us to go behind the scenes and admire the outcome of German discipline and organisation. Into these details it is impossible to enter, but to those who are interested in the industry the volume will prove a veritable storehouse of facts.

The manufacture just described has a serious competitor in the brown coal briquette process, the

material for which occurs very frequently in Germany, and possesses the advantage of being capable of briquetting without the application of a special bond. On the other hand the brown coals—plant tissue which has not proceeded to complete decomposition—contain very much water, usually about 50 per cent., much of which is not simply hygroscopic but belongs to the chemical constitution of the brown coal itself. For the production of satisfactory briquettes the whole of the hygroscopic water, amounting to some 30 per cent., has to be removed, and it may be necessary, especially in the case of bituminous coal, to carry the drying process still further. This drying appears as an expensive item in the balance-sheet, and it may be said that the development of the German lignite briquetting industry has been rendered possible only by the care bestowed on the methods of applying indirect steam drying. The source, pressure and temperature of the steam—whether waste, saturated or superheated—in carrying out the thermal operations, are all of the last importance, and the description and criticism of the various apparatus in use is the central theme of the professor's work in this section.

The brown coal is usually obtained from open workings, the amount of overburden to be removed being very small. The factory is placed as close as possible to the mine to reduce the expense of conveyance.

Sieving and separation of unsuitable materials have to be effected with some care, especially if pyrites be present, for its partial decomposition can give rise to fires during the drying of the coal, on account of the inflammable nature of coal dust. Accumulation of dust—a frequent cause of fires and explosions—is a constant source of apprehension, requiring continual watchfulness on the part of the staff and scrupulous adherence to preventive regulations. Besides the danger of fires, an atmosphere saturated with brown coal dust has an irritating effect on the eyes and is liable to affect injuriously the liver, spleen and lymphatic vessels. Such drawbacks are not confined to this industry, however, and under favourable circumstances the operations proceed with automatic simplicity. After the coal has been sufficiently sorted the unsuitable material is made to pass to the boiler house, and the briquetting coal to the coal floor of the drying plant, whence it proceeds to the drying appliances arranged below and heated for the most part by fresh and waste steam. The drying is continued till the moisture is reduced to about 12 to 17 per cent. This dried hot coal has to be mixed, cooled, and finally compressed to the required shape and size. This operation is usually effected by a single pressing system—the so-called Exter rope press—with an horizontal open channel mould, into which a press stamp is alternately pushed in and drawn out. Though, as Professer Franke points out, there are many varieties of this form of press—first successfully employed in Ireland—yet the demand for higher pressures above 12 atmospheres has brought into use presses with double slide valve gearing, poppet valve gearing, and the so-called positive valve, which are more economical and possess decided advantages over the older form.

The calometric heating values of these brown coal bricks vary between 4,700 and 5,000 calories per kilogramme, or, expressed as evaporative power, 1 kg. would raise about 5 kg. of water at 0 deg. C. to steam at 100 deg. C., and if special firing arrangements be adopted the quantity of water may be increased some 15 to 20 per cent. This value falls below that of coal briquettes, but in favour of the brown coal it is claimed that the combustion gives rise to less smoke, to absolutely no cinder, and depreciates the grate and boiler plates in a smaller degree than its competitor. As a compensation for the smaller calorific value, the cost of production, and consequently of sale, is less than that of pit coals.

The cost of briquettes per ton is said to be only 7.5 marks, but in this estimate the maximum wages of the staff of mechanics is only 3.5 marks per day, and the price of coal 12.5 pfgs. per hectolitre. These are, of course, pre-war prices, and can afford little guidance in forming an opinion of the present position of the industry. The initial cost of the factory and plant is about 10,000*l.* per briquette press, and interest and depreciation are both taken into account in the estimate of 7.5 marks per ton of briquettes.

If Professor Franke's account is long and at times tedious by reason of its minuteness, his survey is thorough and not uninteresting. Mr. Lantsberry, his translator, has performed his share of the work in a masterly manner, and few would recognise any traces of translation. The illustrations and printing of the book are excellent, and reflect great credit upon the eminent firm of publishers.

Manual of Reinforced Concrete. By CHARLES F. MARSH, M.Inst.C.E., M.Am.Soc.C.E., M.I.Mech.E. and WILLIAM DUNN, F.R.I.B.A., Assoc.Inst.C.E. Third Edition. London: Constable and Co., Ltd. [Price 10*s.* 6*d.* net.]

THIS is the third edition of this now well-known reference book and comprises much additional matter, so that in spite of the omission of the section on block concrete included in the previous editions the pages of text have been increased from the 290 of the first edition to 475 in the third. The authors have divided up their subject-matter under six headings. Of these the first deals with the subject of materials. In this the essential parts of the leading British and American standard specifications are reproduced, with much useful commentary by the authors, whose extensive experience lends an additional value to their notes. The text is very amply illustrated, and there are numerous tables giving the areas and weights of different types of reinforcing materials.

The second section is devoted to methods of construction, as to which the advice given is not only comprehensive but thoroughly sound and reliable. The authors lay special stress on the use of rigid moulds which will not deform in use. These moulds must, moreover, be simple and easily erected and removed. The sketches showing different methods by which these ends may be attained will prove of great service to readers. A number of methods by which the attempt has been made to confer on concrete a more pleasing surface than it naturally possesses are fully described. Much valuable advice is also given as to the precautions to be taken at the overlaps or joints of reinforcing bars. The construction of ferro-concrete piles and pipes is also discussed, and the precautions to be adopted in handling and driving them fully set forth.

The third section of the book deals with methods of waterproofing concrete; with its fire-resisting properties, and its liability to possible damage by electrolysis or by certain varieties of sewage.

With section four the question of design is entered into. The preparation of this chapter must have involved much labour on the part of the authors, who appear to have studied every important paper read on the subject during the past 10 years. Moreover, in many cases the formulas given have been reduced to diagrammatic or tabular form, from which values can be obtained directly without the necessity of computation, with its attendant risk of possible arithmetical errors. Almost every possible application of concrete in structural work is dealt with, the examples treated of ranging from floors, grain bins and water tanks up to ordinary beams, continuous girders and gallows frames. The sections on columns, beams and slabs will prove particularly useful, owing to the comprehensive tables and diagrams provided. The Chicago regulations for concrete slab floors are reproduced textually. In dealing with the question of eccentrically loaded columns the authors reproduce Mr. Dunn's graphical method, which was described in our issue of December 25, 1908. All the illustrative cases shown appear, however, to be cases in which the eccentricity produces bending about one only of the principal axes of the column. It would have been well to discuss the more general case, so as to point out the dangerous trap into which the unwary are then likely to fall. In the section on arches the authors assume, as has been usual in the past, that the work done in compressing the arch ring is negligible. It is now becoming recognised that this is not always legitimate.

A collection of useful general rules and tables forms the last chapter of the volume, which will undoubtedly form an indispensable unit in the library of the engineer or architect interested in reinforced concrete.

BOOKS RECEIVED.

Employers and Workmen: A Handbook Explanatory of their Duties and Responsibilities under the Munitions of War Acts, 1915 and 1916. By THOMAS ALEXANDER FYFE. Second edition. London and Edinburgh: William Hodge and Company.

The "Shipping World" Year Book, 1917. Edited by EVAN ROWLAND JONES. London: The *Shipping World* Offices. [Price 10*s.* net.]

The Aviation Pocket-Book for 1917. By R. BORLASE MATTHEWS, Assoc.M.Inst.C.E. Fifth Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 4*s.* 6*d.* net.]

How to Lay-out Turret Lathe Tools: A Handbook for those who design Tools for use on Turret and Capstan Lathes, and Automatic Turning Machines. Coventry: Alfred Herbert, Limited. [Price 2*s.* 6*d.* net.]

A Rational Wages System. By HENRY ATKINSON. G. Bell and Sons, Limited. [Price 1*s.* net.]

The Railway Year Book for 1917. London: The Railway Publishing Company, Limited. [Price 2*s.* 6*d.* net.]

The Locomotive Engineer's Pocket Book and Diary, 1917. London: The Locomotive Publishing Company, Limited. [Price 2*s.* 6*d.*]

Directory of Paper Makers in the United Kingdom for 1917. London: Marchant, Singer and Co., 47, St. Mary Axe, E.C. [Price 1*s.*]

"The Electrician" Electrical Trades Directory and Handbook for 1917 (Thirty-fifth Year). London: *The Electrician* Printing and Publishing Company, Limited, 1, Salisbury-court, Fleet-street, E.C. [Price 15*s.* net.]

"The Electrical Review's" Electrical and Allied Trades Directory, containing a Complete Record of all the Industries directly or indirectly connected with Electricity and Magnetism and the Names and Addresses of Manufacturers in Great Britain, India, the Colonies, Central and South America, certain Continental Countries, &c. London: H. Alabaster, Gatehouse and Kempe, 4, Ludgate-hill, E.C. [Price 1*l.* 1*s.* post free.]

Organisation Physiologique du Travail. By JULES AMAR. With a Preface by HENRY LE CHATELIER. Paris: H. Dunod et E. Pinat, 47 and 49, Quai des Grands-Augustins. [Price 18 francs.]

Electric Traction: A Treatise on the Application of Electric Power to Tramways and Railways. By A. T. DOVER. London and New York: Whittaker and Co. [Price 18*s.* net.]

The Properties of Aerofoils and Aerodynamic Bodies: A Text-Book for Aeronautical Engineers, Draughtsmen and Students. By ARTHUR W. JUDGE, A.R.C.Sc. London and New York: Whittaker and Co. [Price 15*s.* net.]

Modern Milling: A Practical Manual on Milling Machines, Milling Accessories and Milling Operations. By ERNEST PULL. London and New York: Whittaker and Co. [Price 7*s.* 6*d.* net.]

Manufacturing Costs and Accounts. By A. HAMILTON CHURCH. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 21*s.* net]

Riveted Boiler Joints: A Treatise on the Design and Failures of Riveted Boiler Joints, with Numerous Original Diagrams enabling the Designer to Design any Desired Joint without Calculations. By S. F. JETER, B.S., M.E. New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

The Calculation and Measurement of Inductance and Capacity. By W. H. NOTTAGE, B.Sc. London: Wireless Press, Limited, Marconi House, Strand, W.C.; Glasgow: James Brown and Son, Darnley-street. [Price 2*s.* 6*d.* net.]

The Calculations for Steel-Frame Structures Designed to Comply with the Requirements of the London County Council (General Powers) Act, 1909. *With Notes on the Application of Theory to Practical Design.* By WALTER CYRIL COCKING, M.C.I. London: Scott, Greenwood and Son, 8, Broadway, Ludgate, E.C. 4. [Price 3*s.* net.]

Bulletin of the Imperial Earthquake Investigation Committee. Vol. VIII. No. 3. Tokyo: Imperial Earthquake Investigation Committee, Department of Education.

The Interpreters. By GEORGE INCE. London: Constable and Co., Limited. [Price 2*s.* net.]

THE DE-TINNING OF OLD CANS.—It is stated that in pre-war times between 40,000 tons and 50,000 tons of old tin cans were annually exported from this country to Germany, where the tin was recovered and the sheet metal left behind worked up again in the steel mills. In other cases the tinplate was merely cleaned and used up anew in various ways. Works for carrying out similar processes here are now being established at Southwark and Wandsworth. At these places the local authorities will collect the tins found amongst the garbage daily collected and hand them over to a company for treatment. At a conference on the subject held at Caxton Hall last December Mr. M. L. Jones stated that the price paid for such waste by the Germans before the war was about 1*l.* per ton. At Wandsworth the works will be placed near the garbage destroyer, and the corporation will participate in any net profits made. It is stated that about half the "tins" are light iron tins, 20 per cent. are light scrap galvanised iron, and 30 per cent, are enamelled iron or burnt tins. All are to be dealt with and converted to useful ends.

15,000-KW. THREE-PHASE TURBO-ALTERNATOR FOR LOTS-ROAD POWER STATION.

SOME ten years ago builders were considered greatly daring in constructing turbo-generators developing 5,000 kw. at 1,000 r.p.m. The improvements made during the past few years in the design of generator details have, however, been so marked that the 15,000 kw. developed at the same speed of rotation by the unit recently erected at the Lots-road power station is now reckoned well below the maximum output possible for the speed. This machine has been constructed by Messrs. C. A. Parsons and Co., Limited, of the Heaton Works, Newcastle, to the order of the Metropolitan District Railway Company and the London Electric Railway Company, who jointly own the power station at Chelsea. Messrs. Merz and McLellan, of London and Newcastle-upon-Tyne, have acted as consulting engineers to the railway company, preparing the designs and specifications and superintending the construction of the whole of the plant, including the condensing apparatus and the river conduit, and conducting the careful tests made to establish compliance with the terms of the contract.

A few years ago price was the governing consideration in most turbine contracts, as few engineers realised the prime importance of the highest practicable efficiency in power-station plant, and still fewer understood that each successive increase in this efficiency has to be purchased more and more dearly, the cost of a turbine of, say, 68 per cent. efficiency ratio being about one-half that required for an efficiency ratio of 75 per cent. This comparison refers, of course, to the turbine taken *per se*, exclusive of valves, pipes and other accessories. As the load factor at stations has risen it has become more and more profitable to expend capital in reducing fuel costs. According to one American estimate each reduction of $\frac{1}{10}$ of a lb. of coal in the production of 1 kw.-hour will, in power-station practice, be cheaply purchased at an enhanced capital outlay of 2 dols. per kilowatt of plant installed. Fortunately, however, no such sacrifice as this has been necessary, modern high-efficiency turbines costing even less than their predecessors of a decade ago. This has been rendered possible by the improvements already referred to in the construction of generators, which have enabled the output for a given speed to be remarkably augmented.

The pressure and superheat available at Lots-road are relatively low as compared with those standard at certain more modern stations. Hence, whilst in view of future possible changes in the boiler plant the turbine was required to be capable of working with steam supplied at a gauge pressure of 200 lb. per square inch and a temperature of 600 deg. F., it was specified that it should run its trials with steam supplied at a gauge pressure of 185 lb. per square inch and at 500 deg. F., giving a superheat of 125 deg. F. only. The steam consumption per kilowatt-hour is thus about 7 per cent. more than it would be if the tests were carried out with the higher limits of pressure and temperature above quoted. Moreover, although a 29-in. vacuum is contemplated as the normal, the turbine was required to be capable of developing a 50 per cent. overload with steam supplied at 175 lb. gauge pressure and with a vacuum of but 28 in. as measured at the flange of the turbine exhaust pipe. The plant was required to be capable of taking a continuous overload of 20 per cent. and a momentary overload of 50 per cent. more than its normal rating. The steam consumption under test was not to exceed the figures quoted in the table given in the next column.

It should be noted that the turbine was required to provide the power necessary for the excitation of the generator, but not for the other auxiliaries. Taking the generator efficiency (including excitations) as 95 per cent., the consumption per brake-kilowatt developed at the turbine shaft becomes 11.4 lb. per hour, corresponding to a brake-efficiency ratio of 77.5 per cent., using Callendar's tables, or of 78 per cent. if the steam tables in common use are employed. The discrepancy between the two would be larger were the superheat higher, as the values for the specific heat of superheated steam determined from Knoblauch and Jakobs' experiments are notoriously in error.

A longitudinal section through the turbine and generator is reproduced in Fig. 1, Plate XLVIII, whilst Figs. 8 and 9 and 10 and 11, on Plates XLVII and XLIX, are reproductions from photographs taken when the machine was in course of erection. As will be seen, the overall length of the turbine is 46 ft. 4 in. It is divided into a high-pressure and a low-pressure section, the latter being constructed on the double-flow principle. This has several advantages: it makes it easy to provide steam-way for the enormous volume of the steam discharged at the high vacuum specified, and in the second place perfect end balance of the rotor is obtained without the use of dummies. The subdivision of the turbine into high and low-pressure elements halves the unsupported length between bearings, thus raising the critical speed of the rotors, and by the consequent stiffness makes it possible to reduce clearances over blade tips and thus minimise leakage losses. Further, it becomes easier to meet a requirement of the specification that no individual element of the machinery should weigh more than 40 tons. The limit of weight was fixed by the circumstance that the two travelling cranes at the power station have a capacity of but 20 tons each, and were parts of the plant heavier than could be lifted by the conjoint action of these cranes there might be difficulty in the examination and repair of the plant.

Steam Consumption under Various Conditions.

Load.	Steam Consumption lb. per Kw.-hour.		
	With Normal † Vacuum, Steam Pressure, Temperature, Voltage, and Speed.	With Normal Steam Pressure, Temperature, Voltage and Speed, Vacuum Reduced to 2-in. Absolute Back Pressure.	With Normal Steam Pressure, Temperature, Voltage and Speed, Vacuum Increased to 1-in. Absolute Back Pressure.
50 p.c. of *Economical Output	13·2	14·35	12·9
75 p.c. of *Economical Output	12·45	13·4	12·2
90 p.c. of *Economical Output	12·15	13·05	11·95
100 p.c. of *Economical Output	12	12·9	11·8
120 p.c. of *Economical Output	12·45	13·35	12·3

* Economical output = 15,000 Kw. (power factor 95 p.c. lagging) at 11,000 volt.-busbars.
† Normal steam pressure 185 lb. (gauge) at stop valve, normal steam temperature 500 deg. F., normal vacuum equivalent to 1-in. of mercury absolute back pressure as measured at exhaust flange.

As will be seen, the high-pressure section is a single-flow machine, thus making it practicable to use comparatively long blades, in spite of the high density of the steam at this end of the turbine. The first group of blades is 2 in. in height and consists of 15 moving rows, the mean diameter of the blade-path being 40 in. The last group at the low-pressure end of this high-pressure element comprises 11 rows of moving blades $5\frac{3}{4}$ in. long. All blades in this, as well as in the low-pressure turbine, are secured by double caulking.

The body of the rotor is a solid steel forging, 18 ft. $4\frac{1}{2}$ in. in total length, having journals 12 in. in diameter by 1 ft. $11\frac{1}{8}$ in. long at the high-pressure end and 1 ft. $10\frac{1}{4}$ in. long at its low-pressure end. The steel used for this forging was specified to have a tensile strength of from 30 to 35 tons per square inch, with an elongation of 25 per cent. on 2 in. The high-pressure dummy is, it will be seen, a part of the main forging, but the intermediate pressure dummy consists of two discs registered together and to the main body of the rotor as indicated in Fig. 1. Details of the connection are reproduced to a larger scale in Fig. 6. The studs by which this dummy is attached to the rotor are square in the mid-body, and thus secure against any possibility of working loose owing to vibration when running. For balancing the rotor, segmental weights are provided, which are secured in place as indicated at *a*, Fig. 6. Similar provision is made at the low-pressure end of the rotor. A notable feature is the Michell type of thrust block, which is shown in position at *b*, Fig. 1. As will be seen, instead of the numerous collars commonly provided to take care of the end thrust, a single collar only is used. There is a corresponding saving in the overall length of the turbine as well as some reduction in the frictional losses. The main bearings have spherical seats and are arranged so that the bottom brasses can be removed for examination without lifting the rotor. They are lubricated with oil fed under a pressure of 5 lb. per square inch. For this purpose two main oil pumps are provided, arranged at the foot of the governor shafts, as best seen in Fig. 31, page 467. An additional independent oil pump, steam-actuated, is also provided for flushing the bearings when starting up, but this pump is itself capable of ensuring continuously the whole of the lubrication. As a further security provision is made by which the oil supply circuit can be coupled up to the general lubrication system of the station. The usual oil filters and coolers are, of course, also supplied. Waste is prevented by lips cast round the bedplates and base-plates of the bearings, which trap any oil from the bearings which may find a way of escape. Special precautions are taken to prevent any risk of oil creeping from the bearings through the glands and thus into the interior of the turbine, or, conversely, of the escape of condensed steam from the glands into any place where it might mix with the lubricating oil. To prevent either of these *contretemps* special baffles fitting into grooves turned on the shaft are provided. These grooves are illustrated to an enlarged scale in Figs. 4 and 5, Plate XLVIII.

The high-pressure casing is constructed in four principal parts, joined by circumferential and horizontal joints, but by breaking the longitudinal joint the turbine can be opened up as indicated in Fig. 9, Plate XLVII. The details of the turbine have been arranged so that this can be done without breaking any pipe joints or dismantling the governor gear.

The high-pressure end of the casing is built up of steel castings, so that extreme superheats can be carried without danger of the "growth" or distortion to which cast-iron is liable when subjected to varying high temperatures. To ensure against possible warping in service this part of the casing was steamed at 700 deg. F. for a period of 24 hours before being bladed. The steel castings were specified to have a tensile strength of 26 to 35 tons per square inch, with an elongation of 15 per cent. on 2 in. The whole of this end of the casing was, moreover, subjected to an hydraulic test of 330 lb. per square inch. This section of the casing contains both the main steam belt and the overload steam belt (see Fig. 1), the by-passing of the steam to the latter being automatically controlled by the governor. The remainder of the high-pressure casing is of cast-iron, specified to have a tensile strength of 11 tons per square inch, and it was further required that a bar machined to 1 in. square in section, supported on knife edges 12 in. apart, should be capable of carrying a central load of 2,500 lb. After assembly this end of the casing was, moreover, tested by an hydraulic pressure of 30 lb. per square inch. As a final security against warping the whole of the high-pressure turbine, fully bladed and complete with its rotor, was steamed for 24 hours with steam supplied at a temperature of 450 deg. F., the spindle being held fast.

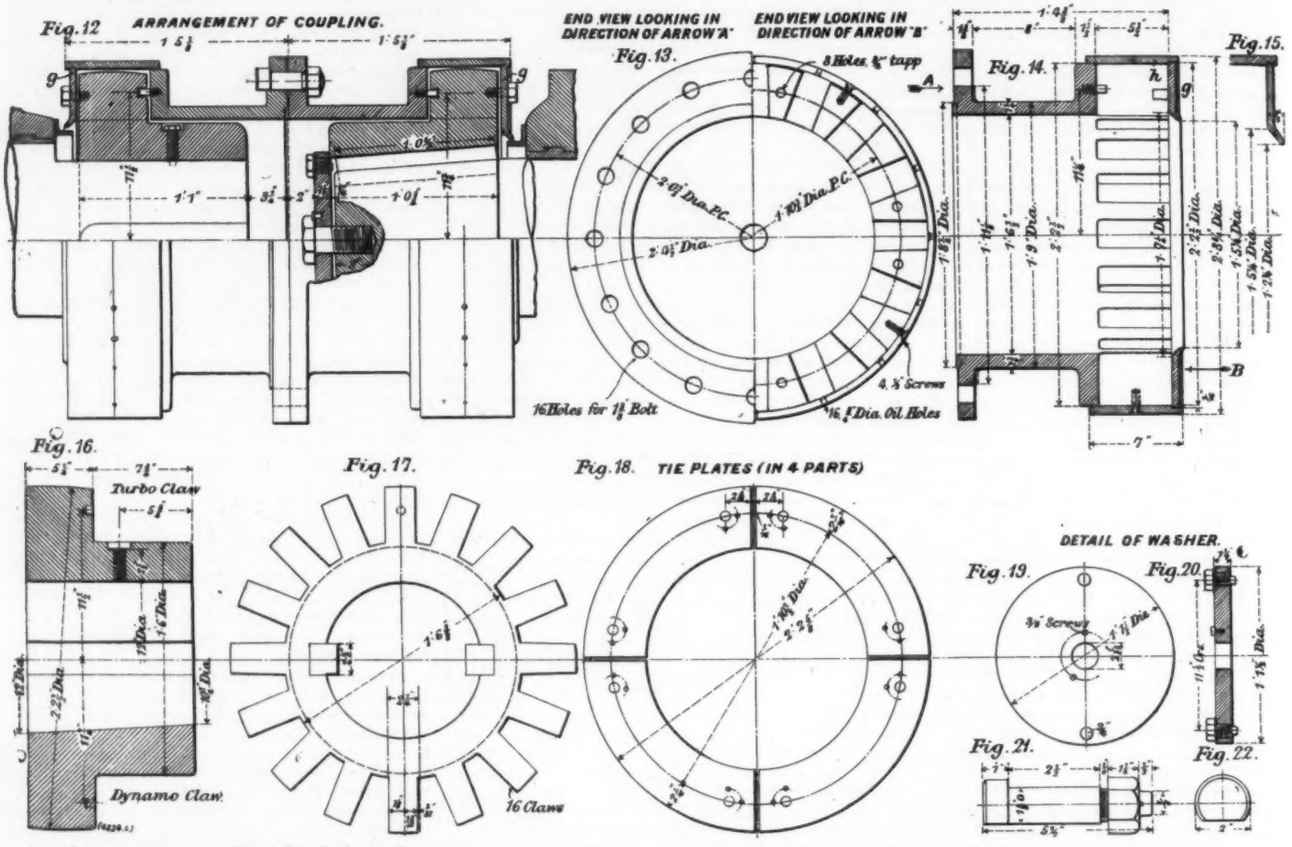
The balance pipe between the dummy after-space and the turbine exhaust is shown in Fig. 1. It is curved in plan, so as to provide for changes in the length of turbine with changes of temperature. This is best seen in Fig 11, Plate XLIX, which, with Fig. 10, also shows the arrangement of the bedplate, which is perhaps not entirely clear in Figs. 1 and 2. A relief valve blowing-off at 15 lb. gauge pressure is provided at the exhaust end of the high-pressure turbine, so that no excessive pressure can ever be transmitted to the low-pressure section.

The low-pressure casing is of cast-iron throughout, the metal being of the same quality as that used for the high-pressure turbine, and, like the latter, the whole casing was, after assembly, submitted to an hydraulic test of 30 lb. per square inch.

As shown in Fig. 1 the steam exhausted from the high-pressure turbine is admitted to a steam belt *e*, provided at mid-length of the low-pressure casing, and thence flows both ways through the blading to

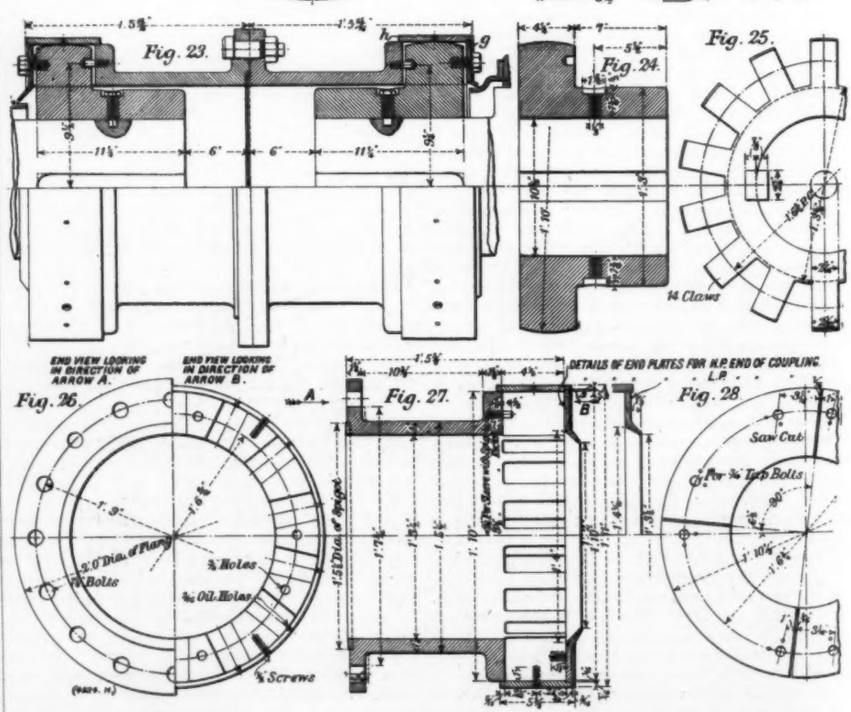
COUPLINGS FOR 15,000-KW. THREE-PHASE TURBO-ALTERNATOR.

CONSTRUCTED BY MESSRS. C. A. PARSONS AND CO., LIMITED, ENGINEERS, HEATON, NEWCASTLE-ON-TYNE.



the exhaust passages at the ends of the turbine. These are connected by a breeches piece with a very large branch on the top of the two condensers, which is, it may be added, suspended from the turbine, and is thus incapable of distorting the latter with variations of temperature. This arrangement is very clearly shown in Fig. 33, page 468. The low-pressure rotor is built up of a number of short drums or wheels. These are steel forgings, similar in quality to that used for the high-pressure rotor. These drums are shrunk on to a mild-steel shaft, as shown in detail by Fig. 3, Plate XLVIII. With this construction the necessary strength to withstand the high centrifugal forces is obtained without the use of a solid drum. The tip velocity of the blades at the exhaust ends is 456 ft. per second, but the specifications demand a factor of safety of 4 at 25 per cent. over speed.

As our engravings show, the complete rotor comprises eight of these wheels or drums, of which four are 65 in. in diameter and the remainder 75 in. in diameter. The shaft, which has a maximum diameter of 30 in., is of 35 to 40-ton steel, having an elongation of 15 per cent. on 2 in. The journals are 15 in. in diameter by 2 ft. $1\frac{13}{16}$ in. long at the end next the high-pressure turbine, and 1 ft. 10 in. long at the generator end. Although there is no end thrust to be taken an alignment block of the Michell type is provided at one end as indicated at *m*, Fig. 1. The two rotor shafts are connected together by a flexible coupling, which transmits torque but is incapable of transmitting any axial thrust; and a similar coupling is used at the generator end. These couplings are illustrated in detail in Figs. 12 to 28, annexed. They are of the standard Parsons type, which has now been pretty universally adopted by builders of all types of turbine. Note should be taken of the oil catchers shown at *g g*, Figs. 12, 14 and 23. These catch the oil flowing out from the adjacent ends of the bearings, and thus ensure the effective lubrication of



the coupling. From the coupling the oil escapes through the holes in the covers, best seen at *h*, Figs. 14 and 23. The exterior of the coupling is smooth, and as the oil is flung off into a roomy casing there is no chance of it being churned into a foam, a *contretemps* which has happened with inferior designs, the heat generated being so large as to disorganise the oil-cooling system.

GOVERNOR GEAR FOR 15,000-KW. THREE-PHASE TURBO-ALTERNATOR.

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Fig. 29.

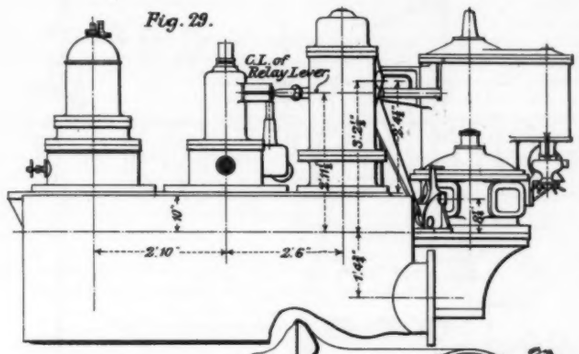


Fig. 30.

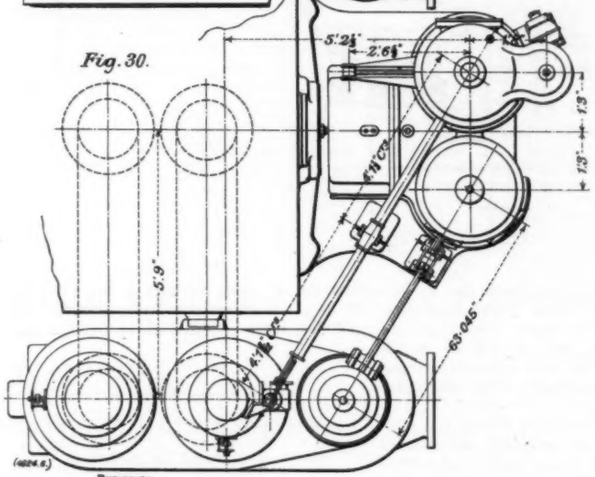


Fig. 31.

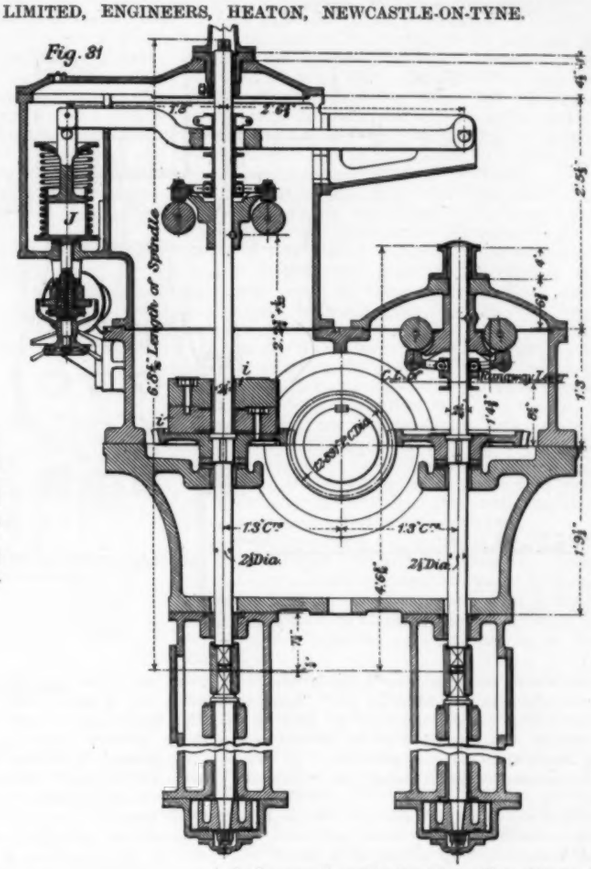
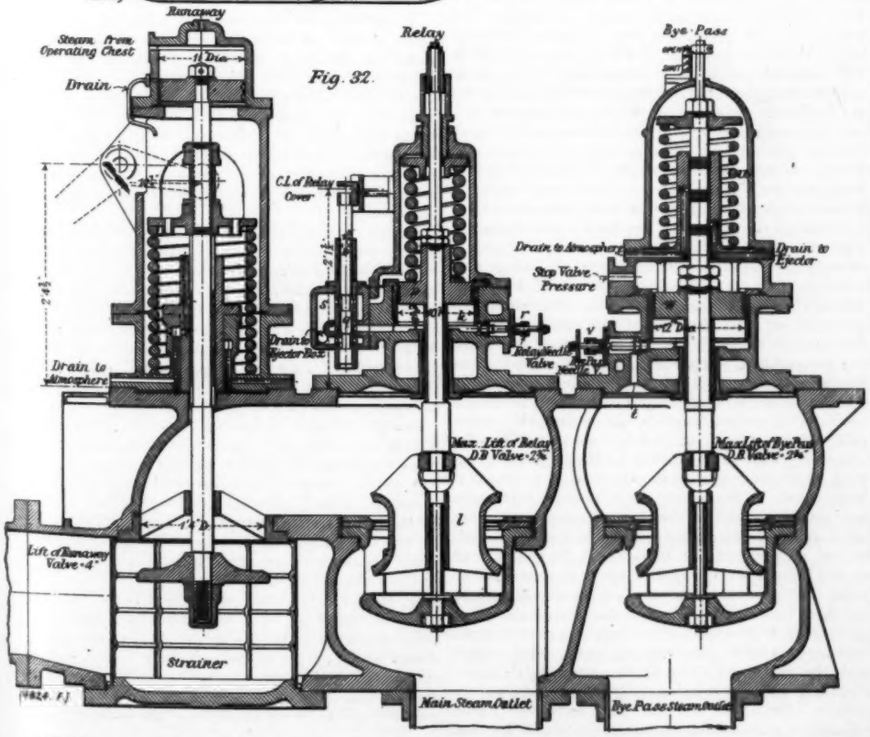


Fig. 32.



In the case of the coupling at the generator end of the shaft, which is that illustrated in Figs. 12 to 22, it will be seen that whilst the one flange of the coupling is shrunk on to a parallel seat, and secured against end motion by set bolts, the flange at the other end fits on to a conical seat so as to be easily removed at need. It is held in position on this seat by the locking-plate shown. In the case of the coupling illustrated in Figs. 23 to 28 the flanges rest on parallel seats at both ends.

The governor gear is illustrated in detail in Fig. 31, annexed. Both the ordinary and emergency governors are of similar type, and are arranged on opposite sides of the worm which drives them. Each governor spindle drives an oil pump at the bottom, through the agency of a muff coupling, as indicated, and each governor can be withdrawn vertically for examination and adjustment without interference with any other working part. To this end the worm wheels are cut away as shown. Since the top of the worm moves from left to right, there is a certain uplift on the left-hand spindle, and to provide for this without compromising the ease with which the governor can be removed, the spindle is weighted as indicated at *i i*. A "speeder," by which the normal revolutions per minute of the turbine can be varied up or down by 5 per cent., is provided at J. This change of speed can be effected from the switchboard by means of an electric motor, as well as by hand from the turbine footplate. The governor is required by the specification to maintain, at normal output, the speed steady within a range of 3 per cent., and the variation must not exceed 4 per cent. when the turbine is developing 20 per cent. overload. The momentary variation when the normal load is thrown on or off is not to exceed 5 per cent., or 6 per cent. when the overload is similarly treated, and in each case the steady speed must be attained within 6 seconds.

The run of the levers from the governors to the controlling valves is clearly shown in Figs. 29 and 30. A section through the valves is reproduced in Fig. 32. The valve on the left is the "runaway" valve, and is normally held open by the lever shown. Should the normal working governor fail and the speed rise to 1,200 r.p.m. this lever is tripped, and the valve, closing under the action of the spring, shuts off steam from the turbine completely. To reset the valve, live steam is admitted above the piston shown at the top of the valve spindle. This forces

15,000-KW. THREE-PHASE TURBO-ALTERNATOR.

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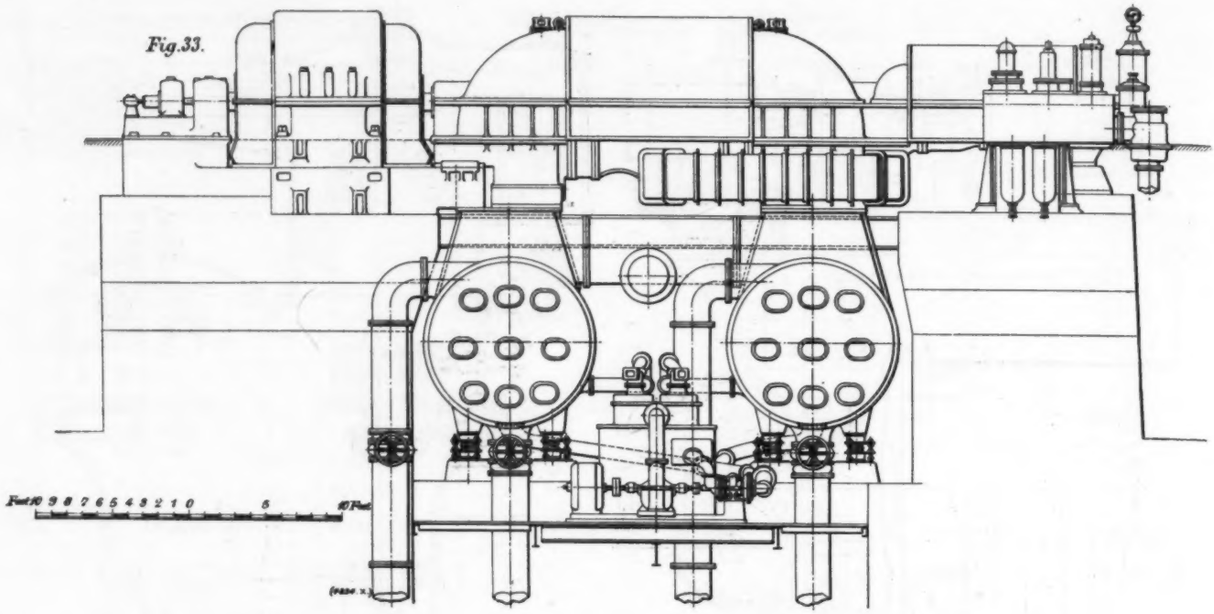
Fig.33.



down the valve until the lever is again caught by the pawl which is controlled by the "runaway" governor. This valve could also be used as the main turbine stop valve, but in the present case a special Hopkinson valve is provided. As will be seen, a strainer is fitted below the "runaway" valve.

The valve shown between the other two in Fig. 32 is that controlled by the main governor. This control is exercised by means of a steam relay in the following way. Through the adjustable needle valve *r* live steam is admitted into the space *k* below the piston *p* and leaks off past the relay valve *q* (of the piston type) into the exhaust chest *s*, and thence to the drain-box. If the piston valve *q* is raised a little by the governor, the steam leaks more freely into the exhaust chest and the pressure falls in the chamber *k*. The main valve accordingly moves down under the influence of the spring shown, thus throttling the supply to the turbine. If, on the other hand, the valve *q* moves down, the steam pressure under *p* rises and the main valve *l* is accordingly opened wider.

The upper ports shown in the sleeve in which the relay valve *q* moves are intended to pass into the exhaust box *s* any steam leaking past *q*, which is made an easy fit in its sleeve, so as to be secure against any risk of sticking.

The by-pass valve shown on the right of Fig. 32 takes steam from below the main governor valve *l*, and when it opens admits steam directly into the by-pass belt *d* of the high-pressure turbine. It is controlled wholly by the pressure below the main governor valve, which is the same as that in the main steam belt of the turbine. A port *t* connects the valve chest with the space under the piston *w*, through the adjustable needle valve *v*. The upper surface of *w* is exposed to the full stop-valve pressure, which is more than sufficient to keep the valve closed against the upward thrust of the spring *s*. The effort of this spring is, however, aided by the pressure under the piston *w*. So long as this is not less than 15 lb. below the stop-valve pressure the by-pass valve remains closed, but as the load increases, the main governor opens wider in consequence; a point is at length reached at which the pressure below *w*, plus the up-thrust of the spring *s*, is sufficient to overcome the live steam pressure above *w*, and the by-pass valve then opens, letting steam pass direct into the belt *d* and short-circuiting the first group of blading. Both the main governor valve and the by-pass valve are, it will be seen, of the double-beat type. The upper seat is held in place merely by the steam pressure above it, since it is loose on the plate below. It is thus free from expansion strains and centres itself automatically with the valve when the latter closes.

All these valves have cast-steel bodies and were required to withstand an hydraulic pressure of 500 lb. per square inch, being hammered with a 2-lb. hammer when under test. A similar test was made of the pipes, and repeated after assembly, but at the lower pressure of 400 lb. per square inch. The exhaust piping and valves were required to withstand a test of a similar character, but under an hydraulic pressure of 30 lb. per square inch only. For the water and oil services an hydraulic test of 150 lb. per square inch was demanded before assembly and one of 50 lb. per square inch when erected; the hammer test being made as before, whilst the system was under pressure.

Sections through the generator are shown in Figs. 1 and 7. It is, it will be seen, completely enclosed, ventilation with filtered air being provided by fans at each end of the rotor. The excitation voltage is from 110 to 125. The exciter is mounted on an extension of the rotor shaft, as indicated in Fig. 1. Provision is, however, also made for independent excitation, should the need arise. The windings are arranged so that the shape of the current wave is a close approximation to a sine curve, being almost free from harmonics. Provision is made by which the voltage generated can be varied in steps of 50 volts from 10,500 volts at no load to 11,500 volts at the maximum overload of 50 per cent. A high standard of inherent regulation was demanded. The rise in voltage on throwing off a non-inductive load of 15,000 kw. is not to exceed 20 per cent., or 30 per cent. in the case of an inductive load of 15,000 k.v.a., the power factor being 0.95 per cent. The momentary stator current on short-circuit of the alternator terminals when generating 11,000 volts at no load was required not to exceed 15,000 amperes maximum peak value, and the sustained value of the current, if short-circuited when developing 15,000 kw., was not to exceed 1,750. The machine was, moreover, to be capable of maintaining an output of 22,500 kw. for a period of 5 seconds. The temperature rise in normal working was not, at normal output, to be more than 36 deg. C. with the inlet air at 15 deg. C., or 39 deg. C. when the inlet air has a temperature of 40 deg. C. When developing 18,000 volts a rise of 7 deg. more is permitted by the specifications.

(To be continued.)

ON WAKE-STREAM AND SUCTION.

By C. H. HOLST.

IN addition to what has been assumed in a previous article* as being the direction of the flow of water at the stern of a ship some further considerations may here follow, which are in aid of the original assumption. Those who have gained experience in connection with steamers or power-boats navigating on shallow and narrow waterways, so frequently met with in Holland, are quite familiar with the phenomenon of "suction," a phenomenon which is seldom experienced when navigating on the open sea.

Masters of canal boats know fully well that when their vessel represents a comparatively large area of midship section as compared with the section of the canal, they have to be very careful to keep the head of their ship in the middle line of the waterway, and that when overtaking another vessel they both do best to slacken their speed, so as to avoid very grave risks of collision or grounding. They also know that when meeting another vessel this risk, although present, exists in a lesser degree.

Boards of canal companies prescribe strict regulations as to certain speeds not being surpassed, so as to protect themselves against damages occurring to the banks of their property, and, generally speaking, inland navigation is the proper school for studying the dreaded symptoms of suction, wash, or how else these inconveniences may be called, which are rarely encountered by sailors.

The views set forth by different people connected with inland navigation differ widely as to the probable cause of this well-recognised nuisance. Some attribute it to the action of the bow-wave, others to the action of the propellers, others to the irregularity of the canal banks, or to the irregular depth, but, curiously enough, little attention is generally given to the influence of the wake-stream,

* See article "On the Differences in Effect of Twin Screws when turning 'Inwards' or 'Outwards,'" published on page 415 *ante*.

which, in the author's opinion, is the true and only cause of it.

When studying the phenomenon on board the vessel, it will be found that in front of the ship, if the bow be pretty bluff, a rising of the water-level is to be observed—the finer the bow the shorter the distance in front will be—whereas the water-level shows distinct symptoms of depression near the after-body.

This rising of the water-level is clearly demonstrated as occurring over a pretty wide distance in passing small rowing boats moored to the banks. These appear to be lifted bodily, but without any violent pulling on their moorings. Gradually, as the ship passes the moored boat, it sinks down again, but to a greater depth than the original water-level, which condition is clearly visible if the boat be moored to a small landing platform on the boards of which the regular watermark is indicated by the growth of water plants, and so on.

This sinking sets in as soon as the midship section of the steamer has passed the moored boat, and gradually increases; it is combined with a violent pulling at the moorings and a backward movement, as well as by a movement towards the steamer. Once the steamer has passed, the little boat rises again with the water-level and comes back to its original position. This series of effects is illustrated in Fig. 1.

Also when passing parts where the banks are gently sloping into the water and covered with reeds, as is often the case in Dutch canals, the stems of the reeds may be seen being pushed gently towards the bank and the water rising between them, up to about the midship length; and, again abaft the midship section, the water rushes out and the stems incline towards the canal, and floating impurities are swept out from between the reeds and remain in view, until pretty nearly behind the ship everything is restored to peace and to its original place.

Another symptom, but worthy to be noted, is offered by the foam created at the bow of the steamer. On long stretches of perfectly smooth water you may follow the lines of foam and bubbles, forming two exactly parallel lines at a mutual distance of some metres in excess of the width of your steamer, not unlike the wake left behind after the passage of a paddle steamer.

Only in the case of short and bluff boats, principally when bluff at the stern, will it be observed that the lines of foam approach each other near the stern; yet very rarely are they found joining into one compact mass unless the propellers of such ships are "churning" the water into an additional width of foam behind the ship.

One more evidence in favour of these views may be furnished by the common practice of ferrymen putting passengers on board of passing steamers at small riverside stations where no regular stops are made. These men row out in small boats up to the middle of the river and await the approaching steamer, keeping their boat head to the tide, but in as near a line as possible with the stem of the steamship. When quite near, the bow-wave pushes the rowing boat gently aside, oars are laid in, and the ferryman, taking hold of a rope thrown from the steamer's deck, brings his boat and passengers safely alongside, often just behind the paddle boxes. The passengers being helped on board, the rowing boat sheers off from the bigger vessel and is almost directly out of danger to be taken by the wake-stream, as at a couple of feet only from the steamer's side the ferryman takes up the oars again and pulls back towards the shore, whereas the steamer puts on "full speed" again as soon as the towing rope is let go.

Do not these simple facts teach us some valuable lessons as to the movement of the water in the vicinity of a moving ship?—Lessons which may be summarised as follows: The bow of each vessel drives a quantity of water before it, in a direction normal to the curvature of the water-lines of the fore body. The water thus set in motion is at once retarded by setting in motion other particles of water by mere contact with those originally touching the ship. This retardation extends over a certain distance from the ship, dependent on the original velocity of the disturbed particles, *i.e.*, on the speed of the ship. The water being retarded, the ship at its uniform speed overtakes the retarded water and so apparently "cleaves" the water, whereas in reality it drives the water in front of itself.

The quantity of water thus displaced and set in motion in each second must be equal to the immersed area of the midship section, multiplied by the length of advance in one second, thus equalling the volume which would have to be dug out from a solid to displace the ship over the same distance.

At the same time as the midship section is moved over a certain distance ahead there remains an equal volume of water to fill up the space which would be left open at the stern when moving the ship in a solid matter. This volume of water cannot be composed of the same particles as those that were driven in front of the bow. Other particles which were at rest near the stern rush in from the sides and in a direction ascertaining the shortest possible way towards their destination, *i.e.*, in lines normal to the curvature of the water-lines of the after-body.

The ship leaves this moving water behind her, and the original wave set up by the bow, as well as the surrounding water, spreads over the surface from which the water was taken to fill up the original hollow created at the same time as the bow-wave.

Instead of the retarding influence met with by the bow-wave before it reaches the canal bank, there is an increase of velocity from the bank towards mid-channel to be expected near the stern. The more gentle the slope of the bank, the greater the distance over which the required quantity of water has to flow in a given time, as the depth fails to produce the necessary quantity within a short distance.

Where sufficient depth is available the whole process of retarding the motion at the bow and of filling up the hollow at the stern is effected in a period of time so short, and extending over so small a distance from the ship, that the foam created at the bow is at rest and not subject to any transverse movement when passed by the stern, hence the two lines of foam show no tendency to approach each other.

In a short vessel with bluff after-body the "filling-in" cannot begin until the full stern has nearly completely passed. At the generally slow speeds of such vessels the distance to which the foam is thrown away from the bow is only insignificant, hence in these cases parts of that foam-covered surface flow towards each other from each side of the ship.

In this way it may be explained that canal banks may be considerably damaged by the wake of a steamer passing near-by at a comparatively great speed. The "rushing in" of the water "gnaws" at the banks; the bow-wave can only cause a deposit of floating impurities to "touch" them.

It now remains to be considered how the steering is affected by the motion of the water, and how, when touching the bank, it is always the bow that comes into contact with it and not the stern.

As a matter of fact no master of a canal-boat will steer his ship into the bank unless this should be necessary to avoid a greater danger, so generally it will be only necessary to consider what is likely to happen when a ship, steering a course *parallel* to the bank, is getting too near the one side of the channel.

The bow-wave will be travelling on as usual; the retarding effect of other particles of water can only be assisted by the influence of the shallower depth, but this extra retardation does not interfere with the direction of the ship. But inasmuch as the cross-sections of the after-body require a continually increasing velocity of the water flowing towards it to fill up spaces which continually increase in volume up to a certain maximum, there will be a stronger influence of current nearer to the stern than immediately abaft the midship section.

This current, coming in from sideways, remains normally fed from the side of mid-channel, but the nearer the vessel may be to one of the banks, the greater the want of water on that side will be, and thus the required volume of water begins to flow in partly in a direction from aft, as indicated in the diagram, Fig. 2, annexed. The perfect balance between the two opposed currents, one acting on each side of the after-body, is then no longer maintained, whereas this balance remains maintained at the bow, consequently the stern is turned more towards mid-channel, causing the bow to run into the bank. The rudder affords no help in this event; on the contrary, its tendency is to do the reverse. Say, for instance, that the vessel is dangerously near to the starboard bank, then the rudder will have to get starboard helm to make the vessel sheer off, but as this means that the rudder itself is turned to port, it offers a greater surface to the current rushing in on the starboard quarter, and thus assists in driving the stern in the wrong direction.

In the case of one vessel overtaking another the same causes will have the same effect unless the distance between the two be sufficiently great to keep each clear from the other's influence, or unless the speed of the overtaken vessel be very much reduced.

Let us suppose, again, that the overtaken ship be on the starboard bow of the overtaking vessel. As soon as the starboard bow-wave of the overtaking ship comes within the influence of the flow of water closing in on the port side of the foremost vessel the resistance against the two sides of the bow becomes unequal, as the port bow of the aftermost vessel continues to meet the original resistance, whereas at the starboard bow this resistance is diminished by the motion of the water flowing towards the stern of the foremost ship, thus creating a suctional influence on the bow-wave and drawing

Fig. 1. STEAMER PASSING A MOORED BOAT.

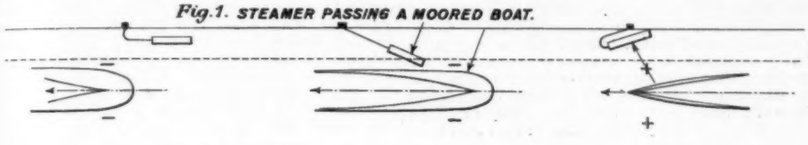


Fig. 2. STEAMER RUNNING INTO BANK.

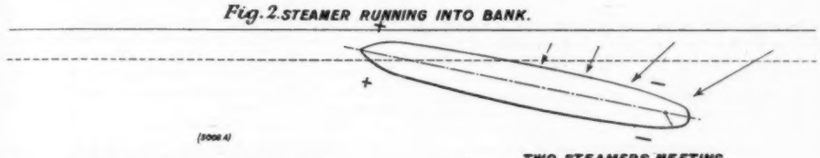
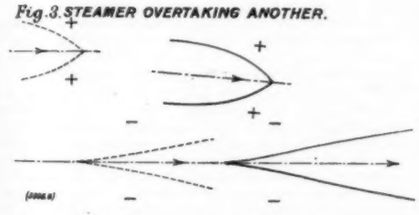
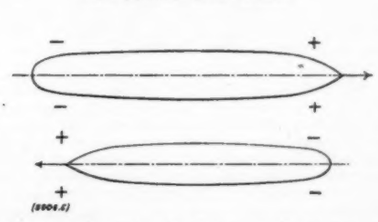


Fig. 3. STEAMER OVERTAKING ANOTHER.



TWO STEAMERS MEETING.



the bow out of its safe course (see Fig. 3). Dependent upon the lengths of the two vessels, but supposing the overtaking one to be the shorter, there will necessarily be a moment when the filling up of both stern hollows can only be fed from astern, and the combined influence of the lesser pressure on the starboard bow and the extra pressure at the starboard stern will drive the overtaking ship helplessly into collision with the foremost. If the foremost ship be the shorter of the two the same danger will only be encountered somewhat later, the stern hollow of the longer ship then drawing the bow of the shorter towards her by diminishing the bow resistance on one side only.

Bearing in mind the volumes of water which play their part in this condition, accidents are easily explained. In the case of the Olympic-Hawke disaster, for instance, there will have been a quantity of between 1,500 to 1,600 tons of water flowing in one second towards the Olympic, a quantity fully sufficient to diminish very seriously the pressure on the corresponding side of the Hawke's bow, whereas on the opposite bow there remained the pressure due to the setting in motion of perhaps some 1,000 to 1,200 tons per second. No wonder that the consequences of this state of things were disastrous to both vessels.

And may not the cause of the lamentable Titanic disaster be explained as well by the same reasoning? Supposing this vessel to have been steaming in a direction parallel to the iceberg which tore up its side to such an enormous extent, the phenomenon described as of common occurrence in inland navigation must then have repeated itself, "a want of water between the ship and the floating mass of ice," and the splendid powerful ship was driven towards its inevitable doom.

When two vessels are meeting each other in a parallel direction the circumstances are quite different again. As indicated in Fig. 4 the two bow-waves meeting in opposite direction have a tendency at first to drive the two vessels from each other, and there remains only the danger of touching each other sideways in a far less serious way than in the case just considered.

This latter risk is explained when it is considered that in passing each other there will be acting on each ship an unbalanced lateral pressure working from outside at the moment when the bow-wave of the one ship will encounter the stern hollow of the other at the adjoining of each. The different conditions here considered will be clearly illustrated by referring to the diagrams on page 469.

INDUSTRIAL NOTES.

IN an interview with the Press last Monday Dr. Addison emphasised the impossibility of dealing with shop stewards and local committees individually. The Government must, he said, be in a position to negotiate on labour matters with the responsible executives of the unions. More than 80,000 shops in 20,000 establishments were concerned, and it would be quite impossible to come to an understanding with each collection of shop stewards. Dr. Addison also stated that the strikes were particularly affecting deliveries of big guns, tanks, aeroplanes and motor transport wagons, and that the continuance of the offensive in June depended upon these. Three weeks had already been lost over certain important guns at Barrow, and the loss of those now being kept back would have to be paid for by our men at the front during next June and July. Dr. Addison made it quite clear that there could be no question of going back on the schedule of protected occupations. The trouble in the London area appeared to rest solely on this schedule, but in other parts of the country grievances centred more on the dilution scheme. With regard to the calling up of men he made the point that no man would be taken out of his occupation in any case unless he was passed for general service. No man would be taken before he had been medically examined, and then only "A" men were to be called up.

As a class shop stewards suffer from the temptation to justify their existence by discovering evils even when none exist. Many, moreover, owe their positions more to the gift of a certain rough eloquence than to the possession of common-sense, or of the scientific spirit which investigates first and acts afterwards. The vaguest rumours are credited without inquiry, amongst others the statement that the new regulations were to remain in force for seven years after the war. The following official statement, therefore, of what the effect of the new regulations will be should be placed on record:—(1) In those firms in which the Bill will apply it will be possible to release skilled men on private work for service on munitions work, by their becoming War Munition Volunteers. (2) The removal of these men would have a serious effect on the industry and throw a number of workpeople out of employment. It is proposed, therefore, to introduce substitutes to take their places. This can only be done if the Government are given the same power to introduce dilution on certain private work as they now possess in regard to munitions work. The object of the Government is to keep private industries alive in order to maintain private trade for home and export purposes. The men who have been recruited from these industries, either for the Army or for munitions work, will thus at the close of the war be able to return to their former occupations. (3) It is not intended that the provisions of the Bill shall continue to operate after the war. The Bill makes the same provisions for safeguarding the interests of the men and the restoration of pre-war conditions as is secured in the case of munitions work. (4) The Bill also provides machinery for preventing rate-cutting, for extending the scope of national wages awards, and for expediting the settlement of disputes. (5) The Bill is not intended to secure skilled men for general service in the Army. Their position is already protected by the schedule of protected occupations. In that connection it should be specially noted that no skilled man or apprentice who is employed in an occupation covered by the schedule, irrespective of whether he is engaged on war work or not, will be recruited till any male diluted labour of military age liable and fit for general military service employed in that occupation in that munitions area has been recruited.

In connection with the present labour unrest the Government wish it to be clearly understood that in any firm in which a part only of the men have struck work the rest of the work of the firm should be kept going as long as possible in order to avoid a number of men being thrown out of employment through no fault of their own. It is further suggested that in cases where women or men are thrown out of work as a result of a strike and find themselves in financial difficulties in consequence, firms might consider the question of making a temporary advance in wages to tide the persons concerned over the difficulty.

One of the demands made has been that membership of a given union should carry with it exemption from conscription. Another proposal was that before any man should be taken at all who could be taken under the schedule of protected occupations all the other men who had come into the shops in the area by dilution should be taken first. This meant that if joiners aged 39 and in the B and C classes had come into an aeroplane factory, they should be taken for military service before a Class A man of 22 who might be taken under the schedule. The Government could not agree to a demand of that kind. It would be fair to take a dilution man fit for general service before taking the skilled man who was a *bona fide* journeyman, and they had agreed with respect to Class A men that they would take the dilution men first.

The central executive of the Amalgamated Society of Engineers state that neither their Executive Council nor their London District Committee have authorised any cessation of work at the present time either in the London district or elsewhere. It appears, nevertheless, that the trouble has arisen in part from neglect of the society to treat the trade card system fairly. It is asserted that unskilled men with but a few months' experience in working a particular class of machine have been admitted to the society, as a special class, and granted trade cards just as if they were skilled men. There is a great demand for skilled men for aircraft construction, marine engineering and the like, but many of the unskilled could now be employed to better advantage at the front. Having been given trade cards, however, this class resents their withdrawal. In any case a considerable number of skilled men are required by the army, and must be supplied. For the present reliance is being placed on voluntary enlistment with the aid of the unions, but if the numbers thus forthcoming are insufficient it will be necessary to call up skilled mechanics on the same lines as other recruits.

It is gratifying to note that as the true state of affairs is being realised by the workmen, the strike is dying down, and work has been resumed at many places during the past few days. This, of course, was to be expected, as our mechanics are as patriotic as any other class of the community. The unfortunate spirit abroad amongst a certain minority of our industrial classes, which, if not large, is exceedingly vociferous, is, however, well shown by the following quotation from a letter which appeared in the last issue of *The Federationist*: "So far as I can see, it is not national service, but national servility for the workers to make private profit for employers. We as workers would honestly do national service if it was State service, but when you sign the form you become a slave to the private employer, and not the State." As a whole, no class of the community has "profiteered" more successfully than the working classes during the war. Men formerly casual labourers have been taking 8*l.* a week in shell making, but the nation has not complained, though the aggregate amount of the "excess profits" in question must exceed many fold those which are to be taxed to the tune of 80 per cent. during the new financial year. Moreover, past experience gives no warrant to the claim made that "workers would honestly do national service if it was State service." In fact a few years since a well-known waterworks engineer was perturbed by the slow progress made on certain work which was being carried out by direct labour. On speaking about the matter, he was frankly and squarely told by the workmen that they never had worked as hard on direct labour as when working for a contractor, and they never meant to, as they recognised that the contractor had to make a profit. Again, when there was a strike of municipal employees at Leeds, just over three years ago, it was found that 708 volunteers, of which one-half were untrained volunteers, gave the same output of gas as the 948 experienced workmen normally employed in the gas works. In fact it was found that the general slackness of the men, working for the community and not for private profit, was such that 4,500 men were required to do the work for which, with fair dealing, 3,500 to 4,000 should have sufficed. The main trouble with most of our would-be social reformers is that they find it less laborious to rely on plausible hypotheses than on a systematic study of historical facts. The saving of effort thus involved is, however, more than counterbalanced by the unreliability of their prognostications as to what will happen in assigned conditions.

The Press Bureau has issued the following statement as to the origin of the London 'bus strike:—

In September, 1913, the London General Omnibus Company, Limited, agreed to recognise the London and Provincial Union of Licensed Vehicle Workers as representing its employees upon the definite condition that the company was not to be embroiled in any dispute with any company with which it had no concern, this clause being specially put in by reason of the fact that the union was mainly representative of the taxi-cab industry, and it was thought that the carrying of London's people should not be imperilled by a dispute which might occur in a competing trade. In January, 1917, the union signed a minute at the Ministry of Labour that they would not use the union's machinery in defence of men who broke the printed agreement with the company. On May 3 and 4 the union informed the company that by the instruction of the annual delegate meeting just held they withdrew from the before-mentioned clause of September, 1913, and repudiated the signature of their organising secretary to the minute of January 5, 1917, which they said would not be regarded as binding on the union. The application made for a war bonus of 10*s.* per week for drivers and conductors, and of 5*s.* for the skilled and semi-skilled garage staff, was placed before Sir George Askwith for the Committee on Production last month, and but for the strike the application would have been heard this week. The company has not withdrawn from that arbitration, and has informed Sir George Askwith to that effect. The case cannot be proceeded with until the men resume work. It should be noted that the omnibus company has acted with great consideration to the dependents of the men called up. In addition to supplementing the Government allowances the company replaced the men withdrawn by their wives and sisters wherever practicable, so as to cause the minimum of difficulty in reinstatements after the war. The majority of the men here, as in other callings, no doubt mean to be fair and just, and when they realise the true condition of affairs the strike will collapse. The real difficulty here is that certain officials of the union wish to exploit the community. When a dispute occurs with, say, some small taxicab proprietor, they wish to compel the community to support them, irrespective of the justice of their cause, by a threat to stop all transport.

The Press Bureau is requested to state that the following statement, which appeared in some newspapers last Monday, is entirely unauthorised and inaccurate:—"War Agricultural Committees throughout the country are being informed that the Government, in order to increase the acreage under cultivation in 1918, have ordered 14,000 tractors and are providing

80,000 men, 60,000 horses, and loaning money to rural councils for erecting houses for farm workers."

According to *The Motor* the new motor tractor is to be known as the M.O.M. tractor, the initials standing for Ministry of Munitions. Several British motor manufacturers will make this new tractor, but opportunities will be given to manufacturing concerns (other than those already decided upon) to tender, and the tractor itself and working drawings will be available for inspection at the Agricultural Machinery Branch of the Ministry of Munitions, 8, Northumberland-avenue, W.C. 2, where any communications on the subject should be addressed. Present plans are for the immediate commencement of manufacture, and the number to be made will be from 6,000 to 10,000. It would thus seem that the basis of the whole business is that the tractor problem is now being taken in hand seriously by the Government for the benefit of the people. The position at the Ministry of Munitions has now been definitely settled. In future there will be two departments of the Agricultural Machinery Branch: the Tractor Machinery Branch; the ordinary Agricultural Machinery Branch. Mr. S. F. Edge is now Controller of the A.M.B. in its entirety.

The Minister of Munitions announces that he does not propose to interfere with the ordinary Whitsuntide holidays. It should be understood that this decision does not apply to such firms as may receive special intimation from any Government Departments with whom they hold contracts that it is essential that they should remain at work during any specified holiday period.

"THE DETERIORATION OF TURBINE BLADING."

TO THE EDITOR OF ENGINEERING.

SIR,—The interesting and instructive paper on the above subject recently read before the South African Institute of Engineers by Mr. A. Fenwick, and published in your issues of May 4 and 11, has justly received a wide publicity in the technical press of this country, and it is to be hoped that our manufacturers and users of turbines will take advantage of such a complete and thorough statement of working results. There is, however, a danger that, in the case of those who are not thoroughly familiar with all the circumstances, doubts and fears as to the reliability of impulse turbines may arise, which will tend unjustly to discredit this type of turbine as built in this country. In the hope that these fears may be removed, we trust that we, as the owners of the Curtis turbine patents for land purposes in this country, may be allowed to place before your readers a few words of explanation and information.

In the first place we are pleased to note that in the preamble to your reprint of Mr. Fenwick's paper reference has already been made to the fact that all the turbines are of one particular firm's make, and that the failures recorded are not due to the type of turbine, but to the use of improper materials or design.

When we took up the manufacture of Curtis turbines about fourteen years ago the blades were cut from solid rings—the material was mild steel, and was found to be serviceable, particularly in the high-pressure stages. Towards the exhaust end, owing to an increasing amount of moisture in the steam, erosion would commence after some 6,000 hours' service. This deterioration was augmented in some cases by ordinary rusting taking place while the turbine was out of service, and due to leaky stop valves, the blading standing in a warm damp atmosphere. Many of these early turbines are still running, and have suffered less in efficiency than would be expected from the appearance of the blading, thus confirming Mr. Fenwick's observations. It was early recognised that a more suitable material was wanted for the blades, and systematic investigations were started by us to find a material possessing the following characteristics:—

1. Non-corrosive in steam and water.
2. Resisting erosive action of high steam velocities.
3. High tensile strength.
4. Retention of initial physical properties.
5. Adaptability for manufacture.
6. Reasonable cost.

It will not be necessary here to relate the methods employed, or give all the results of our investigations. Those interested may be referred to a paper read by our chief chemist, W. B. Parker, F.I.C., before the Institute of Metals (Journal of the Institute of Metals, 1915, vol. xiv), written for the purpose of soliciting the active assistance of the metallurgists towards getting the most suitable material for turbine blading.

Among the non-ferrous alloys we have found that high-grade phosphor-bronze best filled the above-given requirements, and after several years' experience we have found none better. This alloy has initially a yield-point of 12 tons and tensile strength of 24 tons. After being exposed to high steam temperature the alloy ages, *i.e.*, the yield-point is lowered, and somewhat in proportion to the temperature to which it is exposed. This reduction in strength is fortunately not important, as the shortest and least stressed blades are exposed to the greatest heat. We believe the phosphor-bronze has lately been adopted for impulse marine turbines, and with satisfactory results.

The output of steam turbines for a given r.p.m. is gradually growing, and the blading stresses have correspondingly increased, and to such values that the phosphor-bronze alloy is not strong enough for the requirements at the low-pressure end of the turbine. Where this greater strength is required, steel or steel alloys are used.

To avoid corrosion high-percentage nickel steel looked most promising, and was experimentally tried by most turbine builders. Two machines which we built were provided with 25 per cent. nickel steel blading, which came to grief after less than a year's service. The behaviour of this alloy is most mysterious, as pointed out by Mr. Fenwick, and we believe there is no satisfactory explanation to-day as to the real causes of failure, our own investigations being inconclusive. Even with so low a percentage of nickel as 3 per cent. to 5 per cent. trouble may be experienced owing to the tendency of nickel to segregate when pouring the ingot, and we have therefore for some time past been using a high-grade open-hearth carbon steel (having a higher percentage of manganese than usual), so as to obtain a material of great tensile strength, dependable and giving constant results. This steel is not affected by corrosion to any greater extent than steel containing a permissible amount of nickel, and we find that corrosion is not appreciable if the feed water is pure and no deleterious compounds are introduced into the boiler, and, further, that the turbine is kept dry while standing.

It would be desirable, however, if a non-rusting blading material, having great tensile strength, could be obtained. Experiments are in progress in this direction with what is known in the cutlery trade as "rustless steel," but it is too early yet to say if this alloy will stand the test of time.

With regard to nozzle and guide-blade material, there is no doubt that the serious troubles described by Mr. Fenwick are mostly due to employment of 30 per cent. nickel steel alloy, and partly to too thin guide blades. First-stage nozzles exposed to high pressure and temperature with cast-iron division walls, as mentioned by Mr. Fenwick, could only be expected to give the trouble experienced. Bronze alloys have been found most satisfactory for this purpose, especially when used for extra high temperatures, and the extra cost involved is well justified. The most suitable material for guide blades, according to our own experience, is a good grade of mild steel. If a non-rusting steel can be obtained for the longest rotating blades, this material will be equally useful and welcome for the guide blades.

The drop in pressure across a diaphragm is considerable in the first stages of a turbine. Mr. Fenwick mentions a drop of 6 lb. across the diaphragms of turbines in Classes 2 and 4. It should be pointed out that this is the average pressure-difference, and in the case of the first diaphragm the drop is about four times this amount, increasing the stress per blade to four times that given in Mr. Fenwick's table. We believe that cast steel diaphragms should be used where the pressure drop is great, the diaphragm being provided with suitable port-holes, and having separate nozzle segments bolted to the diagram. With this construction all serious bending stresses in the guide blades are avoided, and the extra expense, we think, is justified. Where cast-iron diaphragms are used the metal should be carefully selected so as to avoid excessive growth, which is mostly due to the presence of too much silicon.

In conclusion we would express the hope that the proposed national investigation of blading material will be taken in hand without delay.

(For the British Thomson-Houston Co., Ltd.),
FREDERICK SAMUELSON.

Rugby, May 15, 1917.

"PATENTEES AND THE PROLONGATION OF PATENTS."

TO THE EDITOR OF ENGINEERING.

SIR,—As a mechanical engineer and patentee I was very pleased to see the article in your issue of May 11, page 454, dealing with the question of prolongation of patents which have been harmfully affected by the war. It is a question that should be taken up, and in all common fairness to the patentees should have provision made for obtaining extension in all such cases where the war has interfered with the inventor exploiting his invention.

Many mechanical engineering inventions dealing with complex machinery take years to perfect, and the expense incurred is very great before there is any chance of obtaining any return for the outlay. In cases within my own knowledge complex machines have taken 5, 6, 7 or 8 years to bring to a state of perfection sufficiently so to enable the machines to be placed on the market commercially; and this means, of course, under English patent law, that the return of the outlay and the remuneration for the invention must be earned within a very short period of years.

There are cases within my knowledge where the suspension of exploitation of a patent for two or three years means that the patentee will not receive any reward for his invention whatever, but will rather incur an actual loss, as the balance of time left to him will be insufficient to enable him to reimburse himself for the outlay, and earn a profit.

I can speak with authority in regard to a specialised branch of engineering, the boot and shoe machinery industry, as I fill the position of chief engineer to the British United Shoe Machinery Company, Limited, of Leicester, who manufacture from 180 to 200 different types of machines, many of them very complex and most of them patented.

If there is any movement for taking action to get this matter attended to, I shall be only too pleased to co-operate, either in my private capacity or as engineer to the British United Shoe Machinery Company, Limited.

Yours truly,
ARTHUR E. JERRAM.

"Inglebook," Oadby, Leicestershire, May 15, 1917.

DRAUGHTSMEN AND FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—All credit and the sympathy of the members of various engineering staffs throughout Great Britain are due to Professor Ripper for his candid and slating statement made the other day before the Society of Arts, charging the engineering employers with excessively enriching themselves and overworking and underpaying their draughtsmen and foremen. It is time that a prominent member in the engineering world like Professor Ripper should raise his voice with such a frank and direct statement, especially as since the beginning of the war many selfish employers have, after repeated requests, even now withheld the demand for any increase in the salaries of their technical staffs or even offered to pay them for their largely increased overtime hours, curtailment of holidays, and services, which they have been willing to give and have given without any but the thought of doing their best in the present critical position. Legislation and the trade unions have looked after the interests of the men in the shops; but the staff, not so much out of snobbishness, as often is asserted, but from professional instinct and loyalty towards their employers, have held back from using aggressive trade union methods to enforce their well-merited demands to have their services brought in line with the present changed conditions of living and to receive a fairer share in the profits made by the firms as a result of the exertion of their brains, and to cease to be looked upon as a non-productive community. I wonder how much "production" would be going on without them.

So is it not time the technical staffs take concerted action towards at least those firms who have stubbornly refused to grant any concessions?

I remain, Sir, yours,
"STAFF."

"THE ELECTRICAL PROPERTIES OF GASES."

TO THE EDITOR OF ENGINEERING.

SIR,—To question the truth of any statement made by Sir J. J. Thomson, or to doubt the soundness of his conclusions, would be presumptuous in an ignoramus like me; but, as one who is anxious to learn, I ask in all humility and with proper respect, *how* can it be demonstrated that, concerning the structure of matter, "beyond the chemical atoms which made up the mass of ordinary bodies still smaller systems existed, each chemical atom being *a little universe comprising many planets and suns*"—the italics are mine? Then, again: "We now know that electricity was, so to speak, atomic in structure."

Perhaps Sir J. J. Thomson will, during the course of his present lectures, make everything clear; but, so far as he has gone, there appears to me too much poetry and romance—too much imagination.

May 12, 1915. AN EARNEST STUDENT.

EXPORT STANDARDISATION RULES.

TO THE EDITOR OF ENGINEERING.

SIR,—The recent announcement in the technical press to the effect that the council of this association have issued a set of British export standardisation rules for electrical machinery having unfortunately given rise to misapprehension, I am desired to state that these rules are in no way intended to replace the British standardisation rules for electrical machinery which are issued by the Engineering Standards Committee to cover British-made plant for home and export trade, and in the drafting of which the association is closely and cordially co-operating.

Your obedient servant,
D. N. DUNLOP, Secretary.

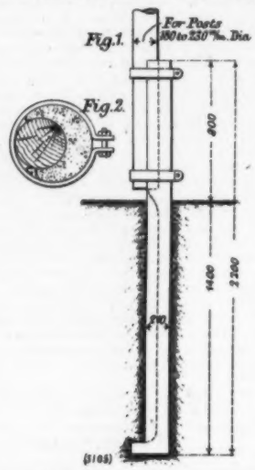
The British Electrical and Allied Manufacturers' Association, King's House, Kingsway, London, W.C., May 16, 1917.

THE BLACK LIST.—A notice issued last Friday contains the names of a number of firms which have been added to the list with which British subjects are forbidden to trade. The majority hail from South America, but a considerable addition is made to the list of those having their headquarters in Dutch territory. There are also many additions to the Spanish and Swedish lists. On the other hand, the prohibition is withdrawn as against all individuals or firms in Japan. Copies can be obtained from the Superintendent of Publications, H.M. Stationery Office, Kingsway, W.C.

CHILIAN SALTPETRE IN 1916.—As regards the trade in Chili nitrate the year 1916 has beaten all previous records. The war had first reduced the production. But the highest production, of 1913, was exceeded in 1916 by 120,000 tons, the total saltpetre mined rising to 2,878,000 tons. Of this, 1,200,000 tons went to the United States, leaving more than 1,500,000 tons for Europe and other parts of the world. Yet it is estimated that the nitrate stores in Chili are hardly smaller than in 1915; we mean the mineral available in the stores, not the mineral in the mines. The methods of mining have been much improved of late.

FERRO-CONCRETE BASES FOR HIGH-TENSION WIRE POLES.

THE frequent rotting of the wooden posts which support high-tension wires for power transmission has induced a Swiss firm (the Siegwart-balken Gesellschaft Luzerne) to introduce ferro-concrete base supports for such wooden posts, so that the portion of the latter which is most subject to quick decay can be kept high and dry. The adjoining sketch shows the method adopted (the dimensions are millimetres). The Swiss authorities have conducted a



series of experiments with these post supports (which are supplied in three sizes) with the following results :—

Size.	For Poles of Diameters of	Weight of Ferro concrete Supports.	Length of Ferro-concrete Supports.	Supports Snapped at a Tension of
	cm.	kg.	m.	kg.
1	18 to 23	200	2.20	5,900
2	22 to 28	280	2.35	6,720
3	24 to 30	350	2.35	8,250

As will be seen by the sketch, the post is held to its support by two clips, but the post itself is not cut, neither are there any holes bored in it.

THE ENGINEERING DEPARTMENT OF THE ILLINOIS UNIVERSITY.—Professor C. R. Richards, professor of mechanical engineering and head of the department since 1911, has been appointed dean of the college of engineering and director of the engineering experiment station of the University of Illinois to succeed Dr. W. F. M. Goss, who has resigned to become president of the Railway Car Manufacturers' Association of New York. Dean Richards is a graduate of Purdue University, 1890, and has been successively instructor in mechanical engineering, Colorado Agricultural College; and professor of practical mechanics, professor of mechanical engineering, and dean of the college of engineering, University of Nebraska.

THE FALLACY OF "LA GUERRE DU COURSE."—In a letter recently published in *The Times* Professor A. F. Pollard quotes from a recent historical work the figures of the losses to our mercantile marine during the last decade of the Napoleonic wars, when, if ever a nation did, we enjoyed the command of the seas. That very command, as Professor Scott points out, involves mercantile losses for the Power which enjoys it; for it is the nation which keeps the sea and not the nation which keeps to its ports that risks its vessels; and while 5,314 British ships were captured by the French, only 440 French ships were captured by the British. Our loss in tonnage was over 40 per cent. of the whole, and that proportion of our modern mercantile marine would amount to 8,000,000 tons. Of course the pace of our losses is greater, but so is the pace of the war. No one expects this war to last for 21 years, and the principal cause of the present stringency is the greater proportion of our mercantile fleet diverted to military purposes. Captain Mahan, we may add, pointed out that the idea of destroying England by the destruction of her shipping was periodically revived during our numerous wars with France. It was advocated as being cheaper than fighting our Fleet and more certain in its results, but in the event it always failed. The most discreditable incident of our own naval history arose from an attempt to beat Holland by the same policy, but the only result was the raid on the Thames and the destruction of Sheerness. In this matter history may be relied on to repeat itself, although the new variant of the old policy may no doubt cause us a certain amount of distress. The only way to beat a maritime nation is to drive its battleships from the seas, which is not to be effected either by attacks on its merchantmen or by "shoot and scoot" raids on harmless pleasure resorts.

THE CASE-HARDENING OF IRON BY BORON.*

By Professor N. TSCHISCHEWSKY (Tomsk, Russia).

ON an inspection of the diagram of iron-boron alloys† it will be seen that on cooling these alloys the boron is not wholly combined in the form of borides of iron, but a proportion of it is left in the form of a hard solution. This phenomenon suggests the possibility of case-hardening steel by boron, similarly to the case-hardening of iron by carbon.

Alloys of iron with boron are remarkably hard, so that they can scarcely be treated on an emery wheel. The technical application of case-hardening by boron suggests itself therefore as a feasible industrial operation. The complete cementation that takes place in carbon steel is not the type of operation the author has in mind, but a surface cementation. It is more convenient to obtain a ferro-boric alloy by melting on account of the high price of boron, and also to secure its complete use without wastage. The use of boron is not perhaps suitable for armour plates, because of its comparative scarcity, but for some machine parts and, generally speaking, where much wear occurs, boron can be applied with success. It must be pointed out that while annealing is necessary in order to confer the necessary hardness on articles case-hardened by carbon, boron confers hardness without the necessity of any special heat treatment.

FIG. 1.
Cubes of iron containing (I) amorphous boron, and (II) powdered ferro-boron.

FIG. 2.
Boric-pearlite with twin crystal structure.

FIG. 3.
Sub-eutectic alloy of ferrite-pearlite.

MAGNIFIED 350 DIAMETERS AND REDUCED BY THREE-ELEVENTHS.

To ascertain the conditions of case-hardening by boron, the author took a sample of iron of the following composition :—

	Per cent.
Carbon	0.12
Silicon	0.02
Manganese	0.16
Phosphorus	0.06
Sulphur	0.04

And as a case-hardening powder pure amorphous boron and a finely powdered rich alloy of iron with boron, containing about 19 per cent. of boron, were taken.

The pieces of soft iron used were in the shape of cubes, holes being drilled in the centre to a depth of about half their length. These holes were filled with fine amorphous boron, or with powdered ferro-boron. The holes were closed by stoppers made from iron of the same quality, these stoppers being pressed home by means of a hydraulic press. The powder being thus compressed, a good contact was secured between it and the sides of the sample, which was thus hermetically sealed. Specimens prepared by this method were heated in a Heraeus furnace in a silica tube. The temperature was measured by a Le Chatelier pyrometer, of which the thermo-junction was placed close to the specimen. In order to eliminate the influence of a gaseous medium, the whole of the air from the silica tube was removed by means of a mercury pump. The samples after heating during several hours showed no trace of oxide on the surface.

Fig. 1, annexed, shows two samples which were heated for two hours at 950 deg. Specimen I contains amorphous boron, and Specimen II powdered ferro-boron. Both samples were cut across longitudinally by means of a steel saw, and the cut surfaces polished.

At the lower part of the photograph are seen the stoppers, which are sometimes marked with thin bands, resulting from the contact with the cement powder left on their sides. The dark area over the stoppers represents the compressed cementing powder. The volumes of the compressed powders decrease partly on account of nodulising, partly owing to absorption by the sides of the specimens. The bands represent an alloy of iron with carbon, and can be seen clearly in the vicinity of the spaces containing the compressed boron or ferro-boron. Under the conditions of the experiment (950 deg. and two hours' heating) the boron penetrated the iron to the depth of 1 mm.

From the experiment it was ascertained that cementation by powdered ferro-boron proceeds more easily and quickly than with amorphous boron. Microscopical examination shows that the hard white layer of the case-hardened part of the specimen consists of compact boric pearlite, with a twin crystal structure.

The photomicrograph of this portion is shown in Fig. 2, subjoined. The edges of this layer contain a sub-eutectic alloy of ferrite-pearlite (see Fig. 3).

The ferrite in this instance contained the boron in hard solution, this being explained in the author's paper dealing with the diagram of iron-boron alloys previously referred to.

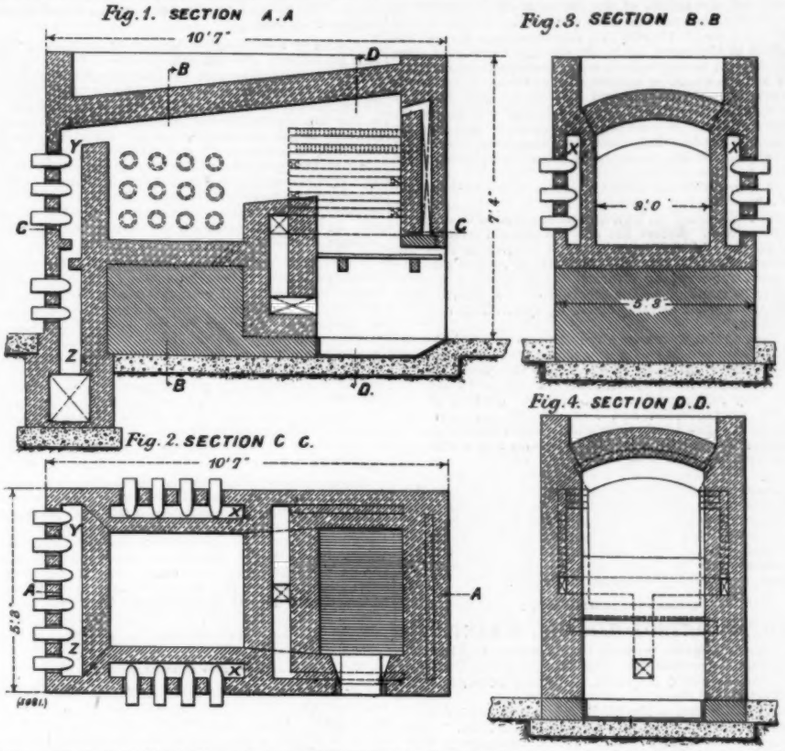
Case-hardening at a lower temperature yields an alloy of iron containing less boron. This alloy is not so hard and brittle as that already described. In order to render the process of case-hardening by boron suitable for industrial purposes, it would be necessary to carry out a series of experiments on the conditions most suitable to the particular purpose in view.

NEW QUEENSLAND COALFIELD. — Mr. Dunstan, Government Geologist, states that the operations in the Bowen coalfield and the analysis of the coal cores from the last boreholes sunk by the Government had shown that the upper 7 ft. 6 in. portion of the Bowen seam in the area prospected by the departmental drilling plant contained on an average about 13 per cent. of ash, while the lower portions, with a thickness varying from 3 ft. 6 in. to 7 ft., had an ash content averaging between 15 per cent. and 23 per cent. The 13 per cent. result was very satisfactory for Queensland coal, although not so low as the best of the Newcastle and Illawarra coals of N.S.W. The test of the coal cores obtained from the bore had shown that the coal in the Government field formed a hard porous coke, and as it had previously been shown that a large area of country was available, as a result of the boring operations, the next feature to be considered would be the fixing of a site for State mining operations. These conclusions had been arrived at after a lot of trouble in investigating all the aspects of the work, and as far as the Government was concerned they might be considered to be final. They also showed that the policy of the Government drills under the department's supervision had been entirely successful, and offered a strong contrast to the work of private companies. Previously the estimate made by himself had shown that in the area prospected by the Government bores, which was over a mile square, 22,000,000 tons of coal would be available, so that nothing more remained to be done, so far as geological survey was concerned, but to undertake the development of opening up the field by a State colliery. Mr. Dunstan states that in regard to the coking qualities of the coal it was possible that the proportion of ash would be between 17 per cent. and 20 per cent., but with coal-washing appliances this percentage might be reduced to 14 per cent. or 15 per cent., and if those results could be achieved, there would be no question about the success of the Bowen field, both as a coal-mining country and a country from which to export large supplies of coke.

* Paper read before the Iron and Steel Institute, Friday, May 4, 1917.

† N. Tschischewsky and A. Herdt, Journal of the Russian Metallurgical Society, No. 4, 1915; *Iron Age*, August 24, 1916.

OGDEN'S COAL-FIRED SHELL NOSE FURNACE.



THE accompanying illustrations show an improved coal-fired furnace, specially designed for reheating shell noses, in use in several munition factories, and built from the designs of Mr. S. Ogden, 372, Fairmount-terrace, Thornley-lane, Reddish, Stockport. The special feature of the furnace is to obviate any possibility of the flame coming in contact with the metal, as this tends to overheat and crack it. To attain this end the side walls of the furnace are doubled, with a space between, and the shells at the outside are placed horizontally in apertures in the outer wall, their noses protruding into the intervening space between the two walls marked X on the plan and one of the cross-sections. The inner wall prevents the flames from coming in contact with the noses of the shells, while at the same time the heat penetrating through the inner wall suffices to take the chill off the shell, and anneals the nose without overheating it. When thus gradually heated up, the shells are transferred and placed horizontally in apertures the nose penetrating into a space between the two back walls, which are marked Y and Z in the longitudinal plan of the furnace, where they come in direct contact with the flames in their passage from the furnace to the uptake or chimney. The temperature here reaches 2000 deg. F. The dimensions of the furnace are given on the drawings, which are practically self-explanatory, and it may be added that one such furnace is sufficient to keep two or three presses going constantly. The furnaces, of course, are built to take any size of shell.

CANADIAN NICKEL.

THE Royal Ontario Nickel Commission, appointed by the Ontario Government on September 9, 1915, to investigate the resources, industries and capacities in connection with nickel and its ores, has presented its report. The commissioners are: Mr. George T. Holloway, Associate of the Royal College of Science, London, and vice-president of the Institution of Mining and Metallurgy, an English metallurgical expert of high repute; Dr. W. G. Miller, provincial geologist; and Mr. McGregor Young, K.C., a well-known barrister of Toronto. Mr. Thomas W. Gibson, Deputy Minister of Mines, acted as secretary. The report is a bulky volume, containing over 600 pages, and is well illustrated with cuts, diagrams and maps. In addition, there is an appendix of 219 pages, which contains the evidence of the witnesses who testified before the Commission, and a number of papers, memoranda, and other matter pertinent to the inquiry.

The Commissioners print a summary of the report and their conclusions on the main points of the investigation at the forefront of the volume, and thus enable the reader to obtain the gist of the report without difficulty. They say: "The two questions that have been uppermost in the numerous discussions that have taken place concerning Ontario's nickel industry during the last 25 years, are (1) Can nickel be economically refined in Ontario? and (2) Are the nickel deposits of Ontario of such a character that this province can compete successfully as a nickel producer with any other country? It will be seen that the Commissioners have no hesitation in answering both of these questions in the affirmative. The nickel ore deposits of Ontario are much more extensive and offer better facilities for the production of nickel at a low cost than do those of any other country."

Public interest in the nickel question has been, and continues to be, very keen. It has been a matter of popular belief that Ontario has a practical monopoly of the world's nickel, and there has been something like exasperation in the public mind because of the fact that none of the nickel mined in Ontario was refined in Canada, but that it was being sent abroad, and mostly to the United States, for final treatment.

The Commissioners say that at the beginning of their inquiry it was asserted by the companies interested that nickel could not be economically refined in Ontario. They, therefore, naturally express gratification at the assured prospect of the erection in Ontario of two large plants for the refining of nickel. One is now being constructed by the International Nickel Company of Canada, Limited, at Port Colborne. The company has obtained a site of 400 acres, on which 2,000 men are now at work, and is erecting a plant whose initial output will be on the basis of 15,000,000 lb. of nickel per annum, provision being made for doubling or quadrupling this capacity. The matte to be refined here will come from the smelters of the Canadian Copper Company at Copper Cliff, for the treatment of which there will be required bituminous coal, coke, fuel-oil, nitre-cake and other chemicals and materials, estimated at 100,000 tons annually. The plant is expected to be in operation and turning out refined nickel in the autumn of the present year.

The second refinery is that of the British America Nickel Corporation, Limited, a company controlled and largely financed by the British Government, which has purchased the large Murray mine, the Whistle, and other deposits in the Sudbury region. This refinery will probably be erected at the Murray mine, which is about three miles from Sudbury. The refining process employed will be the electrolytic, otherwise known as the Hybinette process, from the name of the inventor, who uses it in the Norwegian works. This plant will have a capacity at the beginning of 5,000 tons of nickel per annum. The output of these refineries, added to the nickel now being produced in England from Ontario matte, will fully meet, if not surpass, the entire requirements of the British Empire.

The uses of nickel are dealt with in several chapters under the headings: "Properties and Uses of Nickel and Its Compounds"; "Non-Ferrous Alloys"; and "Nickel Steel and Other Alloys of Nickel Containing Iron." The great use of nickel is in the manufacture of nickel steel, the ordinary form of which contains about 3½ per cent. of the metal. Many useful alloys of copper and nickel are produced and used for a variety of purposes, such as bullet-casings, for coinage, plumbers' supplies, &c. The use of nickel in the electro-plating of metallic objects is widely known, and needs no explanation. As finely divided metal, nickel is used as a carrier of hydrogen in the manufacture of fats from oils, and this property is largely made use of by soap-makers. Pure nickel is used in coins, in making watch and cigarette cases, and cooking utensils. It is also drawn into wire used in spark plugs and electrical leading-in wires.

Chapter IV, on "The Nickel Deposits of the World," contains 191 pages, and is in itself a complete treatise on this subject. The Sudbury deposits are first taken up, and their geology, mineralogy and composition fully discussed. The extent of the ore reserves is given at 70,000,000 tons of proven ore, and of proven, probable and possible ore at 150,000,000 tons. Mining methods are described and illustrated. New Caledonia is generally held up as the chief competitor of Ontario in the production of nickel, and the deposits there are dealt with. The ore is different from that of Sudbury and does not contain copper. It is shown that while there is a good deal of nickel in New Caledonia, the mines are small compared with those of Sudbury. The largest mine yet worked contained 600,000 tons; few exceed 250,000 tons, while in Sudbury the large deposits have tonnages ranging up to 45,000,000 tons. The ores as shipped are richer in nickel than those of Sudbury, but are gradually lowering in tenor; they are more expensive to work; are farther away from markets, and the production is increasing very slowly. While the output of the Sudbury mines has grown ninefold during the last 15 years, that of New Caledonia has increased by only 20 per cent.

The nickel mines of Norway are dealt with. They are of the same character as those of Sudbury, but poor in both nickel and copper. The deposits are small, and the output is not capable of very large expansion. The electrolytic process of refining is employed in Norway, and all the Norwegian nickel since the beginning of the war has been going to Germany.

There are many other countries in the world which contain deposits of nickel ore, including Germany and Austria, France, China, Russia, Egypt, Italy, Tasmania, United States, &c. Most of these deposits appear to be of limited extent. In Madagascar the ores are similar to those of New Caledonia, but have never been worked. In the island of Seoboekoe, near Borneo, and in Cuba, there are large and doubtless important deposits of nickeliferous iron ore. In Seoboekoe they have never been worked, while in Cuba operations have been going on for some seven or eight years. Neither, however, can be regarded as a source of metallic nickel, and the shipments from Cuba do not appear to be increasing.

The Commissioners conclude that while it is true Ontario has no monopoly of nickel, it possesses many advantages over all competitors, even under the present conditions of the market as to prices and trade connections. In any keen competition as to prices it is doubtful whether any locality at present known or suggested could compete with Ontario.

A chapter of the report is devoted to the history and development of the principal operating companies connected with the industry in Ontario from its inception.

Several chapters of the report are devoted to a description of the metallurgy of nickel, the roasting and smelting of the ore and the Bessemerising of low-grade matte. The Bessemer matte contains about 80 per cent. of nickel plus copper, the Canadian Copper Company's product containing about 53.5 per cent. nickel and 25 per cent. copper. That of the Mond Company is lower in nickel and higher in copper, containing about 40 per cent. or 41 per cent. of each. The Orford, Mond and electrolytic refining processes are described and compared, the Commissioners remarking that the respective costs of producing refined nickel from the Sudbury ores by each of the three processes mentioned do not differ to such an extent as to give any one process a material advantage over the others in competition. Costs of production are gradually falling through increased efficiency and larger output, and may be still further reduced. War conditions are for the present exercising an influence in the opposite direction. The use of the electrolytic process, which the Commissioners regard as most suited to Ontario conditions, by all the companies operating in Ontario would not prevent their meeting competition from any other quarter. This process can be operated as cheaply and efficiently in Ontario as in Norway. The Mond Nickel Company give their reasons for not refining in Ontario. These are founded on the greater expense due to higher wages, increased cost of fuel and chemicals, higher freight charges, and the necessity for quick delivery of copper sulphate to Mediterranean ports during the season when it is required.

Some space is devoted in the report to a possible product from the Sudbury ores or slags, namely, nickel-copper steel. There has been a prejudice against the presence of copper in steel, but much recent experimentation has tended to show that this prejudice is unfounded, if the copper content is not too high. Indeed, there is reason to believe that the presence of a limited proportion of copper in steel is beneficial, and also that it is capable of replacing a proportion of the nickel in nickel-steel up to at least one-third of the combined quantity of nickel and copper. Experiments made for the Commission by Professor Guess, of Toronto University, fully confirmed these conclusions. Copper also appears to assist steel in resisting corrosion.

The production of nickel as a by-product was investigated by the Commission. Such production is of considerable importance. By-product nickel comes mainly from the electrolytic refining of blister copper, copper ores almost invariably carrying a small proportion of nickel. About 815 tons of nickel were obtained in

1915 from the refining of copper in the United States, and the tremendous production of copper going on in that country will largely increase this quantity. In addition, scrap metal containing nickel is continually being re-treated and the nickel recovered. The production of by-product nickel, though small in comparison with the output of ores worked for that metal, has much bearing upon possible supplies of non-Canadian nickel for export to enemy or other countries.

The Commissioners point out that the importance of the precious metal contents of the Sudbury ores has not in the past been fully recognised. These consist of gold, silver, platinum, palladium, iridium and other rare elements. The proportions of these metals which the ores carry are minute and appear to vary in the several deposits. Roasted matte from one of the companies showed 0.1235 oz. platinum and 0.197 oz. palladium, 0.027 gold and 1.84 oz. silver, while the other company's matte showed, platinum 0.988 oz., palladium 0.984 oz., gold 0.256 oz., and silver 6.155 oz. per ton. Platinum is at present very scarce and the price unusually high, palladium is being substituted for it wherever suited. Both these metals are now worth at least five times as much per ounce as gold. The Orford refining process recovers a much smaller quantity of the precious metals than the Mond and electrolytic processes. The recovery of the metals of the platinum group constitutes an interesting chapter of the report. It states that the platinum and palladium contained in the Copper Cliff mattes for the year 1916 would be worth 794,600 dols.

Losses in mining, smelting and refining are discussed in the report. A chapter is devoted to statistics of nickel production, showing the output of Ontario, New Caledonia, Norway and other countries. The report seems to cover every conceivable phase of the nickel question, at any rate in relation to industry and trade, and will form a veritable encyclopædia of information for many years to come.

LABOUR ECONOMY.

MR. W. L. HICHENS (chairman of Messrs. Cammell Laird and Co., Limited), speaking at the National Economy Exhibition, Cutlers' Hall, Sheffield, on Tuesday, May 15, on "Labour Economy," said: "It is no exaggeration, I think, to say that our whole economic future is bound up with labour economy; we shall stand or fall according as we embrace new ideas or adhere obstinately to the narrow prejudices which are milestones on the road to destruction. Our commercial supremacy was seriously threatened before the war, and it is certain that the assault will be continued with renewed vigour when peace is declared. A well-considered tariff may protect us from the unfair competition of dumping or may serve to nurse a young and growing industry to maturity, but we shall assuredly find that we have been living in a fool's paradise if we imagine that a tariff is a panacea for all our commercial difficulties. Success or failure must in the long run depend on our own efforts—on our initiative, adaptability and energy, and it is right that this should be so, for it is right that the best man should win. All we are justified in expecting is a fair field and no favour, and that is in fact all we need to ask for. As a nation we are pre-eminent in the qualities that make for commercial success, and we have only to see that they do not become overgrown with the moss of disuse. The long period of our unchallenged commercial supremacy has relaxed our vigilance; we have fallen into the bog of inertia, and it is no easy matter to scramble out again. We have to face the fact that all waste in the production of manufactured goods must be as rigidly prevented as extravagance in the use of our food supplies. This will appear to everyone an obvious platitude, and yet a moment's reflection will show that it is largely ignored in practice.

"It is not merely in minor matters that we are extravagant, although the little economies that might easily be effected would aggregate a large figure. The savings that any large firm could make in lubricating oils, fuels, electric power, lighting and tools, for example, if everyone concerned took a personal interest in checking waste, would secure many an order to this country which under present conditions goes to the foreigner. But it is, of course, visionary under present conditions to expect that the great majority of the employees in any big firm will take a keen personal interest in trying to save money for their employers.

"But now let us take a larger field for saving. Most people nowadays are familiar with the principles of scientific management so ably worked out by Mr. Frederick Winslow Taylor and Mr. F. B. Gilbreth.

"It offers enormous possibilities for economy in labour—not necessarily, let me add, in the payment for labour, which is a very different thing, but of that later.

"Scientific management implies that restriction of output shall be abandoned, for it presupposes that everyone will do his best. There is no doubt, I think, that by far the greatest menace to the future prosperity of this country is the restriction of output which eats like a cancer into the industrial organism. It is easy enough to diagnose the general causes of the disease and to point out that it is bound to be chronic so long as labour has no assured and reasonable share in the increased wealth that it produces. It is easy enough, too, to agree that labour ought to have such an assured and reasonable share, but when we descend from the general to the particular it is a matter of very great difficulty to work out the basis on which a fair distribution of wealth can be made. Perhaps there is no perfect system; perhaps at most we can only hope for a rough-and-ready scheme which will be recognised as a substantial improvement on present conditions. This much is certain; that if labour and capital could compose their differences and really pull together, the results that might be achieved are staggering. Imagine a football team in which every member played as slackly as he dared; in which the forwards were jealous of the half-backs, and the halves of the three-quarters; where no one trusted the captain, and where any section of the team was ready to stop at any moment during the progress of the game while the enemy scored goal after goal, in order to emphasise a real or imaginary grievance. Such a team would be hooted out of existence; it would be covered with ridicule and ignominy. And yet it is just such a team which is trying to run the industries of this country. We can organise for games and practice all the principles that make for organised efficiency; is it impossible for us to apply those principles to the serious pursuits of life

"It is probably no exaggeration to say that if capital and labour worked together as loyally as the members of a football team, our national income could be doubled in a few years. Before the war the annual income was estimated at 2,000,000,000*l.*, and it is obvious that the addition of a like sum annually would render possible the most far-reaching reforms. It is surely far more sensible to combine in the creation of new wealth than to dissipate what already exists by quarrelling over its possession.

"This, again, seems an obvious proposition, but I do not think we can hope for any permanent improvement in the matter of labour economies at the present time. We have mountains of distrust and abuse to remove before any real progress can be made. Just as in the far less controversial and less difficult case of food economy it takes a long time and careful organisation to secure results, so no big labour economies will be effected unless the question is taken up and treated as one of national importance. As a first step, therefore, it is important to emphasise the enormous scope for improvement that exists, and to show how great is the stake from the national point of view for which we are playing. If this is realised I believe that British common-sense will assert itself and that some practical working hypothesis will be found whereby the full fruits of industry can be reaped and shared by all."

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday afternoon, the 16th inst., at 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., president, in the chair.

Mr. J. E. Clark and Mr. H. B. Adames presented their "*Report on the Phenological Observations for* 1916." The year as a whole was rather warm, excessively wet, deficient in sunshine and phenologically disastrous. This arose mainly from the peculiar distribution of wetness and warmth. January was dry in most parts, but February and March among the wettest on record, the precipitation largely as snow. February was colder than January, March than February, and in Ireland and England, S.W., April than January. Cold nights with frost continued well into July, the former half of which, and June, were so disastrously cool that the mean was lower than in May, with a minimum of sunshine. Many days were cooler than many in January. The winter warmth developed abnormal premature growth, seriously damaged by the early spring winter. The extreme wet of that time almost stopped farm and garden work; the cold nights later ruined much of the fruit crop, and the cold summer greatly lessened the quality of the harvest, being also largely responsible for the serious failure of the potato crop, combined with the most abnormal rainfall of the ripening-off and lifting time in late October and November.

The tables largely reflect the above conditions, especially in the earliness of the hazel (two weeks), bringing it well into January (26th), perhaps for the first time; also the long range in date of the hazel, anemone and blackthorn, averaging 97 days, compared with 46 days for the late spring and early summer flowers, hawthorn, ox-eye, daisy and dog-rose. This long range is due to colder districts giving dates after the cold spring break and the earlier some records preceding it.

A very important aspect has so far not been worked out, namely, the areas of equal date of appearance, which may be suitably denoted as isophainal zones. In Great Britain the earliest, before April 29, appears to include South-West Wales, Cornwall, Devon, a tongue stretching up from Hants to Worcestershire, East Sussex, Surrey and Kent. All the rest south of the Mersey and Humber, except a large East Anglian area round the Wash, falls in the zone between 120 and 130 (May 9). The third zone to the 140 isophain covers the rest of England, except Northumberland and Scotland bordering on the Solway. Northwards dates later than May 19 prevail. In Ireland we get the 130 isophain from near Limerick to west of Dublin, and so on towards Newry, that of 140 passing from Clew Bay to Belfast Lough, with a southward bend round Lough Neagh.

NOTES FROM THE NORTH.

GLASGOW, Monday.

Scotch Steel Trade.—Although the demand for munitions may be said to have eased off slightly, there is no actual diminution in the demand for steel material of every description, both finished and semi-finished, required either directly or indirectly for war purposes. Even with every mill running constantly, so very great is this demand that almost none of the ever-increasing output is available for export, the only exception being some small lots to our French and Italian Allies. The growing activity in the shipbuilding yards is throwing a further onus on the steel works, as the demand for the steel angles, shapes, &c., required in connection with the Shipping Controller's orders is very extensive. Naturally, export rates are purely nominal, and might be quoted as at or about 14*l.* 5*s.* per ton for ship plates, with boiler plates 15*l.* 5*s.* and angles 14*l.*, any or all of which are subject to revisal.

Malleable Iron Trade.—Makers of malleable iron are still faced with the difficult problem of turning out in sufficient quantity, and in the stipulated time, such supplies as will meet the demands of their customers. There is no lack of good orders for the home trade, both in the iron and steel departments, and the pressure for delivery is intense, despite the fact that every available bar mill is running at full speed. So far as export is concerned, however, prohibition of the shipment of any iron such as might be required for shipbuilding purposes is certain to have a very decided effect. The current quotations for "Crown" bars run from 15*l.* 2*s.* 6*d.* to 15*l.* 5*s.* per ton, some of the better brands realising perhaps 5*s.* per ton or so in advance of this figure.

Scotch Pig-Iron Trade.—The most notable feature in connection with the Scotch pig-iron trade is the continued heavy demand for all grades, hematite especially being in constant and urgent request, and the entire output is completely absorbed by the local steel works with Government contracts on hand. Although the output is much in excess of that of normal times, it in no way keeps pace with the demand, which could readily make use of a considerably greater production. Shipments, naturally, are limited, and were it not for the licensing restrictions a rich harvest would undoubtedly be reaped from the high export rates ruling at the moment. No. 1 foundry iron is still scarce, and this, added to the abnormal demand, prohibits the accumulation of any stock.

Greenock and Shipbuilding Extension.—Considerable feeling is being manifested in Greenock, both for and against the scheme of extension now being promulgated by Messrs. Caird and Co., with which firm is now incorporated that of the famous Belfast firm, Messrs. Harland and Wolff. Whatever may ultimately come of the proposed scheme, it is one which, if satisfactorily arranged, ought in the future to add very materially to Greenock's industrial prosperity. There are, however, some serious difficulties to be overcome before the property of one sort or another can be acquired to render the extension possible.

THE ECONOMY OF GAS-COKE AS FUEL.—The Deptford Borough Council, during March last year, introduced the London Coke Committee's apparatus for burning gas-coke in the steam boilers at the public baths, and now report the following result of a year's working with coke exclusively as fuel. The cost of coal for twelve months from March, 1915, to March, 1916, at the current price, would have been 1,792*l.* 12*s.* 5*d.* The cost of gas-coke from March, 1916, to March, 1917, has been 1,444*l.* 0*s.* 7*d.*—amount saved, 348*l.* 11*s.* 10*d.* The saving, which is equivalent to 19.4 per cent., would have been greater but for the large increase in the heating and electric lighting of the buildings owing to the very cold and dark winter, and to the increase in the number of warm baths used, estimated at over 9 per cent. The financial saving, despite the adverse circumstances, has exceeded the estimate made by the local gas company who supplied the coke-burning apparatus, which was fitted to the boiler furnaces by the baths staff at a total cost of about one-tenth of the saving effected during the first year. From the national standpoint the saving effected by the patriotic action of the council in using gas-coke in lieu of raw coal is in the by-products recovered by first treating the coal in gas retorts. The by-products recovered from an equivalent quantity of coal so treated include 1,440 gallons of benzol, 9,600 gallons of coal tar, and 10 tons of sulphate of ammonia (fertiliser).

THE HIGH-FREQUENCY RESISTANCE OF MULTIPLE-STRANDED INSULATED WIRE.—At the meeting of the Royal Society on the 10th inst. a paper on this subject was read by Professor G. W. O. Howe. The conductors employed in radio-telegraphy are frequently made up of a large number of fine wires separately insulated and stranded or plaited together in such a way that every wire occupies in turn the same relative position in the multiple conductor. In this way the total current is forced to distribute itself equally between all the wires, even at high frequencies. The object of this is twofold, viz., to make the inductance independent of frequency and to reduce the resistance at high frequencies. It is shown in this paper that the second object is rarely achieved because of the eddy currents induced in the wires by the magnetic flux within the conductor. It is shown that the loss due to this cause is so great that the effective resistance of the stranded conductor is, in many cases, greater than that of the solid wire which could be put in its place. In the first part of the paper formulæ were deduced on the assumption that the eddy currents in the fine wires do not appreciably affect the distribution of magnetic flux within them. In the second part this assumption was not made, and formulæ were deduced which took into account the screening effect of the eddy currents. It was proved, however, that the assumption is permissible in nearly all the cases considered. A number of tables were given in this paper showing the ratio of the high frequency to the continuous-current resistances of straight and coiled conductors of different sizes made up of fine wires of three alternative diameters. These formulæ and tables enable one to see at once if any advantage is to be gained by using such a stranded conductor in any given case, and, if so, the best number of wires and space-factor to employ. The paper showed conclusively, however, that the extended use of such conductors in radio-telegraphy for the purpose of reducing the resistance has no scientific justification.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Items of interest in the local position are few and far between. The circumstances from week to week now show little alteration, principally owing to the automatic way in which deliveries go away either on contract account or on behalf of the Government-appointed district committee which directs supplies to industrial users. Any free coal which finds its way on to the open market is readily purchased. Throughout the whole of the South Yorkshire district there seems to be an ever-increasing demand for best steam hards, probably accounted for by the growing extensions of works. At present this brand is a somewhat short tonnage, but not sufficiently below requirements to cause any serious interference with work. If more steam nuts were available they could be used with advantage. Cobbles have a strong tone, and are a fairly plentiful supply. Slacks are being used in greater quantities, and Lancashire firms are in the market for big deliveries. Gas companies seem more concerned with the question of contract renewals than with the immediate problem of present-day requirements, but collieries appear disinclined to discuss such a matter at the moment, especially when the company concerned is asking for increased deliveries in view of the greater quantity of power they have to provide for munition works. Householders continue more moderate in their demands, and there is a notable falling-off in this section which is very welcome. Outside the tonnage for our Allies there is little business passing in the export trade. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The main characteristic of the metal market this year has been the keenness of the demand in comparison with the tonnage available, and this feature is still very noticeable to-day. Both in pig-iron and also in scrap there is a tightness which points to stringency of supply, and steel makers who are not fairly favourably placed under contract accounts are somewhat perturbed at the tone the position is assuming. Scarcely any Swedish tonnage is offering, and even when any considerable tonnage does come to hand the prices seem out of proportion. Still, if the quantity were there, even excessive price would hardly be allowed to interfere with wholesale purchases. Manufactured steel supplies are hard to get, and the much-spoken-of easier tendency in the steel trade seems as far off as ever it was. Much of the prevailing difficulty in getting orders fulfilled must be attributed to the great call for steel for marine work. Everything that was not of paramount importance at the moment has had to be subordinated to this one interest. The results can be described as satisfactory up to date, but the expansion of output must be more elastic even yet. It is stated that much depends upon this being achieved. Rolling-mills are forging ahead in the task of changing bar rolls for plate rolls, and other important steps are in hand. New and large orders have come to the city. Messrs. Cammell Laird and Co., Limited, and Messrs. Henry Bessemer and Co., Limited, have received orders which amount in the aggregate to 4,500 driving and pony-wheel tyres from the London County Council. It may here be noted that the London authority have granted Messrs. Hadfield's an increase of 3,000*l.* on their contract price for the delivery of certain special trackwork. This is owing to the unexpected advance in the cost of certain materials and in labour. Brightside Foundry and Engineering Company, Limited, have also found a customer in the London County Council for the supply of piping for the new condenser at the Greenwich station. Another firm has got a substantial order for manganese tramway points and crossings from the Derby Corporation. There is still a big trade in spades and shovels for war agricultural work, and implement makers are enjoying a period of unprecedented activity. Overseas trade of a general character is quite up to recent satisfactory proportions.

NOTES FROM THE SOUTH-WEST.

Cardiff.—After the spasmodic boom in the coal market last week a sustained reaction has set in, and the weakening tendencies which have been appearing for some days past have been accentuated. Prices for prompt shipment have been governed entirely by positions and individual circumstances, and quotations nominally rule from 23*s.* 6*d.* for inferior Eastern Valleys to 27*s.* 6*d.* for second Admiralties. The supply of tonnage is still insufficient to cope with the output of the collieries and sidings are once again becoming congested. Quotations, accordingly, have again ruled on the easy side, but only for prompt positions, salesmen preferring to take the risks of the market than commit themselves to any forward sales at the low figures now obtainable. Smalls particularly are weak, but there has been no movement in the other sections of the market, and the following may be taken as the current approximate quotations:—Second Admiralties, 27*s.* to 27*s.* 6*d.*; ordinary steams, 26*s.* to 26*s.* 6*d.*; best drys, 27*s.* to 27*s.* 6*d.*; second drys, 24*s.* 6*d.* to 25*s.*; Black Veins (Cardiff shipment), 26*s.* 6*d.* to 27*s.* 6*d.*; Western Valleys (Cardiff shipment), 26*s.* to 27*s.*; best Eastern Valleys, 25*s.* 6*d.* to 26*s.* 6*d.*; and other sorts, 23*s.* 6*d.* to 24*s.* 6*d.* Smalls continue to command 18*s.* to 18*s.* 6*d.* for best steams, 16*s.* 6*d.* to 17*s.* 6*d.* for best ordinaries, and 13*s.* 6*d.* to 15*s.* 6*d.* for cargo smalls, while other sorts are round about 12*s.* 6*d.* to 13*s.* 6*d.*

Newport.—The undertone for Newport coals has again been weak, and in several cases collieries have experienced great difficulties in keeping their pits fully employed. The scarcity of the supply of wagons is naturally reacting on the supply of empties, and as wagons have been requisitioned for purposes other than those of coal-carrying, this difficulty is becoming accentuated. Under these conditions offers of spot supplies were improving at cut figures, but with little or no result, and unless the offer of shipping improves during the next few days, it is feared that many of the pits will again have to stop working. Pitwood arrivals, also, are not so plentiful this week as they have been recently.

Miners for the Army.—There had been a good deal of perturbation as to what might have been the outcome of the attitude recently adopted by the South Wales miners in their refusal to accept the scheme arranged between the Government and the Miners' Federation of Great Britain regarding the combing-out of underground workmen for the army. At the conference held this week, however, all fears have been dispelled. At a conference of delegates representing the miners, held at Cardiff, by a majority of 20,000 a resolution reversing the former decision, and accepting the scheme, was carried. This decision came as a relief to those who had become somewhat anxious as to the result.

THE GERMAN ALCOHOL INDUSTRY.—At the annual meeting of German spirit manufacturers, recently held in Berlin, it was stated that all the departments of the manufacture—raw materials, alcohol, vinegar, yeast, bottling, fermentation, and fuels—had been busy with general and special war work. The outlook for the future was not considered favourable, since for years to come potatoes would more than ever be wanted as food; a great many of the large farms used to rely more upon potato-spirit distillation than upon farm produce. For incandescent burners alcohol with 15 per cent. of benzene is being utilised; in fuels, alcohol with 25 per cent. of benzene is substituted for petroleum. The sale of petroleum for illumination is at present forbidden in Germany. Acetone fermentation works had been opened in Arenberg, but the technical difficulties of the process had not been quite overcome yet; it is also intended to push the manufacture by fermentation of butyl and other alcohols.

TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.—A new committee, to be known as the Technical Committee of the Motor Industries, has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders in order to co-ordinate the many technical questions which arise in connection with the automobile industry and which have been handled independently in the past. For instance, the Institution of Automobile Engineers formed a Steel Committee over two years ago that did a lot of useful work for the purpose of standardising steels for use on automobiles, and they are also represented on many of the automobile sub-committees of the Engineering Standards Committee. The Society of Motor Manufacturers and Traders have at the same time been represented on those sub-committees, while various other technical matters have been dealt with by their Standardisation, Technical and Research Committee, which has existed for some time. Matters have now been put on a better footing, and a joint permanent committee has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders which will be known by the above title. It is hoped that by this pooling of interests that not only will all overlapping be prevented in future, but that the committee, strengthened as it will be by the addition of representatives nominated by the various Government Departments and institutions, will be recognised by the Council of Scientific and Industrial Research and all concerned as the proper body to treat with in all technical matters connected with the motor industry. Invitations to be represented on the committee have already been accepted by the following:—National Physical Laboratory, represented by Dr. Stanton; General Post Office, by Captain Wheeler; Institution of Mechanical Engineers, by Dr. Hele-Shaw; Iron and Steel Institute, by Mr. J. H. Dickenson; Commercial Motor Users' Association, by Mr. George Watson. The Technical Committee will take over the work hitherto carried on by the Standardisation, Technical and Research Committee of the Society of Motor Manufacturers and Traders, the Steels Committee and the Standardisation Committee of the Institution, and the Research Committee which is carrying out research on the E.S.C. British standard steels for automobiles with the addition of aircraft steels, and which is financed by a Government grant of 1,000*l.* and a donation of 1,000*l.* from the Society of Motor Manufacturers and Traders and the trade generally. The work in the various directions will be carried out either by the existing committees or by specially appointed sub-committees of representative character who will report to the main committees which, in turn, will deal with the Government Department concerned, or with the Engineering Standards Committee. It is hoped that by means of this organisation the voice of the industry will be heard in all the technical problems that are bound to arise after the war. Further information can be obtained from either of the joint secretaries, Mr. Basil H. Joy, secretary, the Institution of Automobile Engineers, 28, Victoria-street, London, S.W. 1; or Mr. T. F. Woodfine, secretary, the Society of Motor Manufacturers and Traders, 83, Pall Mall, S.W. 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Firmness continues to characterise Cleveland pig-iron, but with the arrangements for deliveries to home buyers and to customers in Scotland practically complete under the May allocations, and traders disinclined to commit themselves ahead to any extent, business is quiet. A few forward contracts, however, are being made, some of them over a period extending as far as October. Demand on behalf of our Allies is insistent, and parcels are being despatched to certain destinations as expeditiously as circumstances permit, but new export trade is only small. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all remain at 92*s.* 6*d.*; and No. 1 is still put at 96*s.* 6*d.*; whilst for shipment to Italy and to France No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—There is not much new ascertainable concerning East Coast hematite iron. So far as home needs are concerned the situation is quite satisfactory, supplies being ample and regular, but foreign business is on a very limited scale. Market rates are not quotably altered, but sellers are most emphatic in their declaration that prices are much below what the situation warrants, and are reluctant to book further orders to any extent, especially for export, at the recognised market quotations. Under such circumstances it is not surprising to find a marked upward tendency, and sellers hope and believe that advances will be sanctioned in the near future. At present Nos. 1, 2 and 3 remain at 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Stocks of Pig-Iron.—Makers' stocks of pig-iron are understood to be very small, and the quantity of Cleveland pig-iron in the public warrant stores has now been reduced to 1,879 tons, composed of 1,873 tons of No. 3 quality and 6 tons of other descriptions of iron deliverable as standard.

Furnaces in Operation.—The number of blast-furnaces in operation on the North-East Coast has recently been increased by blowing-in an additional one on hematite, and now stands at 78. Of these, 35 are turning out Cleveland pig-iron, 29 are making hematite, and 14 are producing special kinds of iron.

Manufactured Iron and Steel.—Manufacturers in the various branches of the finished iron and steel industries continue working at very high pressure, with the result that the huge output is still being steadily increased. Demand from the shipyards is heavy, and supplies thereto are growing. There is little material to spare for export, and shipments are being made to our Allies only. Prices all round are strong. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 18*l.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Coke.—The plentiful supply of coke has no weakening influence on values. Demand is heavy, especially for local consumption, and descriptions needed for the blast-furnace continue to realise the fixed maximum prices, average furnace kinds selling at 28*s.* at the ovens, and 30*s.* 6*d.* at the ovens being the quotation for qualities low in phosphorus.

Output of Ironstone.—The executive of the Cleveland Ironstone Miners and Quarrymen's Association met this week and discussed at length the question of increasing the output of ironstone. They expressed the opinion that the association's communication with the Ministry of Munitions as to the release of Cleveland men from the colours had not been satisfactorily acknowledged, with the result that the officials had no knowledge as to what was happening. A resolution protesting against other than Cleveland men being drafted into the district was adopted, but to prevent an open rupture in the industry the miners were advised to continue quietly at work for the present, with the assurance that they would be kept fully informed as to developments.

A.E.G. TURBINES AT SHANGHAI.—We recently published a record of the many and continuous failures, due to indifferent engineering, of the A.E.G. turbines supplied to the Rand power companies. We have now received the annual report of Mr. T. H. U. Aldridge, the electrical engineer to the Shanghai Municipal Council. In last year's report some disastrous experiences with two A.E.G. turbines of 2,000-kw. capacity were recorded, and the present report states that during the past year one of the 5,000-kw. units supplied by the same builders has established a similarly unedifying history of failures. In fact the plant has proved so unsatisfactory that it was considered necessary to include in contracts with the more important consumers a clause authorising a limitation of the supply should the necessity arise. Advantage had to be taken of this clause on several occasions during the year covered by the report. The new machinery on order is being obtained from Great Britain and from the United States, and will consist of one 10,000-kw. unit built by the General Electric Company, another of the same size by Messrs. C. A. Parsons and Co., and a 5,000-kw. plant supplied by Messrs. Fraser and Chalmers.

KEYSTONE ALL-STEEL PULLEYS.

MESSRS. W. A. WALBER AND CO., ENGINEERS, LONDON.

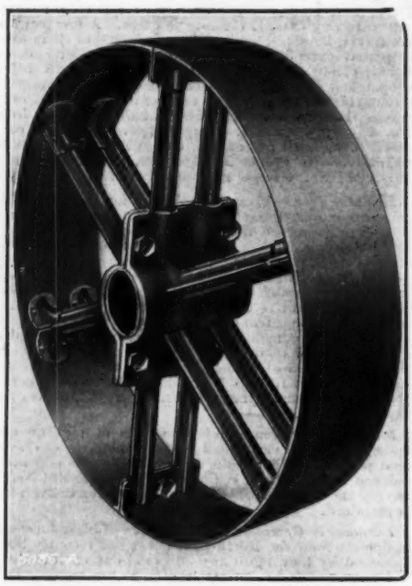


FIG. 1.

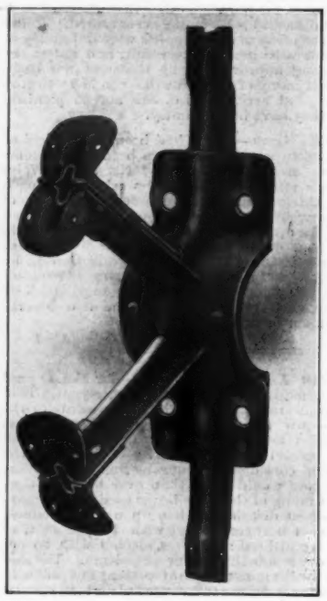


FIG. 2.

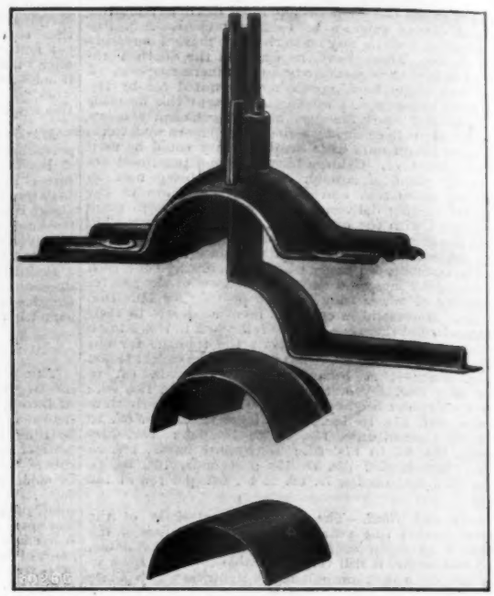


FIG. 3.

THE introduction of high-speed steel has created a demand for strong pulleys in those cases in which a direct electric drive is not used. Deeper cuts and higher speeds require wider and heavier belts, and to meet these requirements, without overloading the shafting with weight, new designs of pulleys have been got out. The most recent of these is illustrated in the annexed engravings, which show a built-up pulley of light weight and great stiffness, every part of which is pressed in dies, so that it is exact in form and capable of being turned out with little expense for labour. The pulley is made in halves, although this feature is not very clearly shown in the engraving. A steel plate of the required width of the pulley is stamped into a semicircle with its ends turned inwards radially to form flanges which can be bolted together. Two of these semicircles form the complete rim, and are carried by six or twelve arms, according to the width, except in the case of very small pulleys, which have only four arms. The set of six arms is formed of six pieces, each piece comprising the halves of two adjacent arms set at an angle of 60 deg. In each half-pulley there are three of these double arms (Fig. 2), the centre piece being riveted to the other two, and the three making a single structure which is very stiff and can be relied upon to distribute the strains equally among its members. Before the riveting is carried out the arms are threaded through slots cut in pressed steel half-bosses, the ribs on the connecting piece between the two members of a V lying snugly in recesses stamped in the boss. This arrangement is shown more clearly in Fig. 3, which illustrates a four-arm pulley in process of assembling. It illustrates how all the parts lend mutual support to one another when clamped together.

To the ends of two of the arms angle-pieces are riveted to connect them to the interior of the rim (Figs. 1 and 2), while the remaining half-arms are riveted to the flanges on the ends of the half-rims. The result is half of a split pulley, and two such halves can be connected together by four bolts in the boss, and two in the rim.

The split pulley is not applied directly to the shaft. A split steel bush having a centre corrugation (Fig. 3) is laid inside it and a plain bush inside that. Inside this another bush with heavy flanges on to which the two halves of the split pulley are clamped (Fig. 4). The pressure is so great that no key is needed. The thickness of the flanges depends of course on the diameter of the shaft, since all pulleys of a certain size are made with an eye large enough for the biggest shaft they are likely to be used with. For smaller shafts the flanges on the bush are much thicker.

These pulleys are being introduced by Messrs. W. A. Walber and Co., of 38, Victoria-street, Westminster, under the name of "Keystone." A large plant has been laid down for their manufacture, and they are stocked from 5 in. to 36 in. in diameter, varying by inches, and from 3 in. to 12 in. in width. Odd sizes can be produced at a day's notice. As all the pieces are stamped, they are exactly to gauge, and run quite truly and in balance, while they are much lighter than the ordinary round-arm pulley of equal strength.

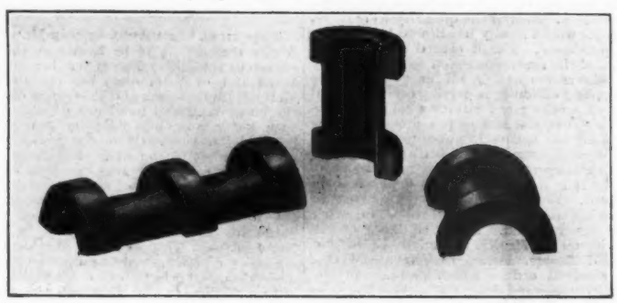


FIG. 4.

CONCRETE ROADS AFTER THE WAR.—The council of the Roads Improvement Association, of which Prince Arthur of Connaught is president, at a meeting held in London on Tuesday last, resolved to act upon a recommendation that investigations should be made forthwith into the claims of concrete roads. The council of the association is in possession of much interesting data, from America and elsewhere, concerning the economy and durability of concrete roads with reinforced concrete foundations. Instructions have now been given by the association for a report to be prepared and presented by Mr. H. Percy Boulnois, M.Inst.C.E., formerly city engineer of Liverpool and Deputy Chief Engineering Inspector to the Local Government Board.

THE GENTLE HUN.—The name of Professor Flamm, of Charlottenberg, is well known to British naval architects and shipbuilders, from whom in years past he received many courtesies. The following indication of the kind of "angel" they were entertaining unawares is therefore not without interest:—"*Die Woche* has an article by Professor Flamm, of Charlottenburg, advocating harsher treatment of neutral ships, with the object of intimidating them to remain at home and leave the British to risk their own ships. Such a reaction upon British tonnage (the professor writes) could be more quickly enforced if fewer men of the crews of torpedoed neutral vessels were saved. The best would be if destroyed neutral ships disappeared without leaving a trace and with everything on board, because terror would very quickly keep seamen and travellers away from the danger zones and thus save a number of lives.—*Reuter.*"

TRADE WITH FOREIGN NEUTRAL COUNTRIES.—The following notice is officially announced:—Certain articles have appeared in the press recently with reference to information which is being collected by the Foreign Trade Department of the Foreign Office from His Majesty's Consular Officers abroad. This information relates to firms in neutral countries with whom British houses could trade in place of firms of enemy origin or association which have been placed on the Statutory List. The reports from His Majesty's Consular Officers will give the names of firms desirous of trading with the United Kingdom, with references, bankers, commercial reputation, general nature of business, method of transport, principal goods immediately required, and whether the firm trades on own account or on commission basis. The following bodies have agreed to disseminate the information: The Association of Chambers of Commerce of the United Kingdom, Parliament-mansions, Orchard-street, S.W. 1, and its associate Chambers of Commerce; the London Chamber of Commerce, 1, 2 and 3, Oxford-court, Cannon-street, E.C. 4; the Federation of British Industries, 39, St. James's-street, S.W. 1; certain approved trade associations and federations not associate members of any of the above organisations. Firms who are members of the associations enumerated above should apply for the information through one of these channels. The Foreign Trade Department reserve the right to refuse the information, in consultation with the Board of Trade, to any firm not British in character or dealing largely in articles competing with British manufactures. His Majesty's Consular Officers have also been instructed to send duplicates of their reports to the Board of Trade, and the information will therefore also be available at the office of the Department of Commercial Intelligence of the Board of Trade, 73, Basinghall-street, E.C. 2.

15,000-KW. TURBO-ALTERNATOR FOR LOTS-ROAD POWER STATION.

CONSTRUCTED BY MESSRS. C. A. PARSONS AND CO., LIMITED, ENGINEERS, HEATON, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 465.)

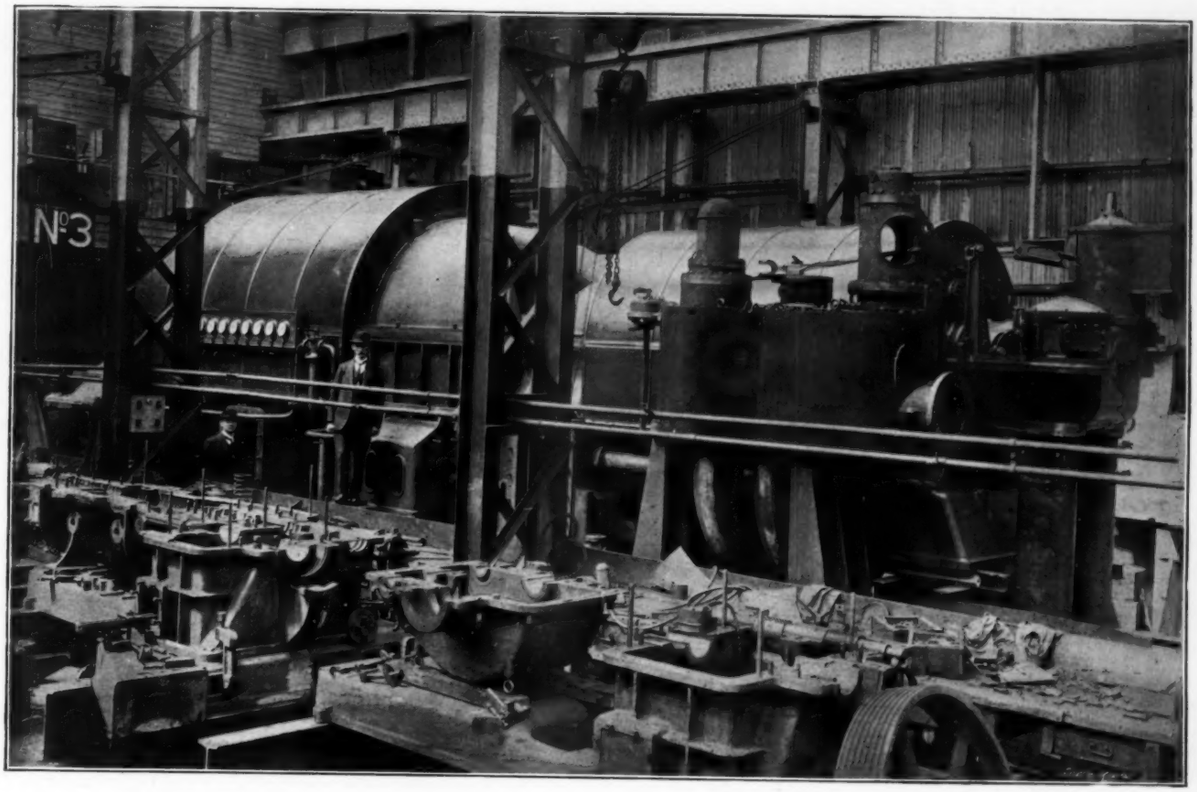


Fig. 8.

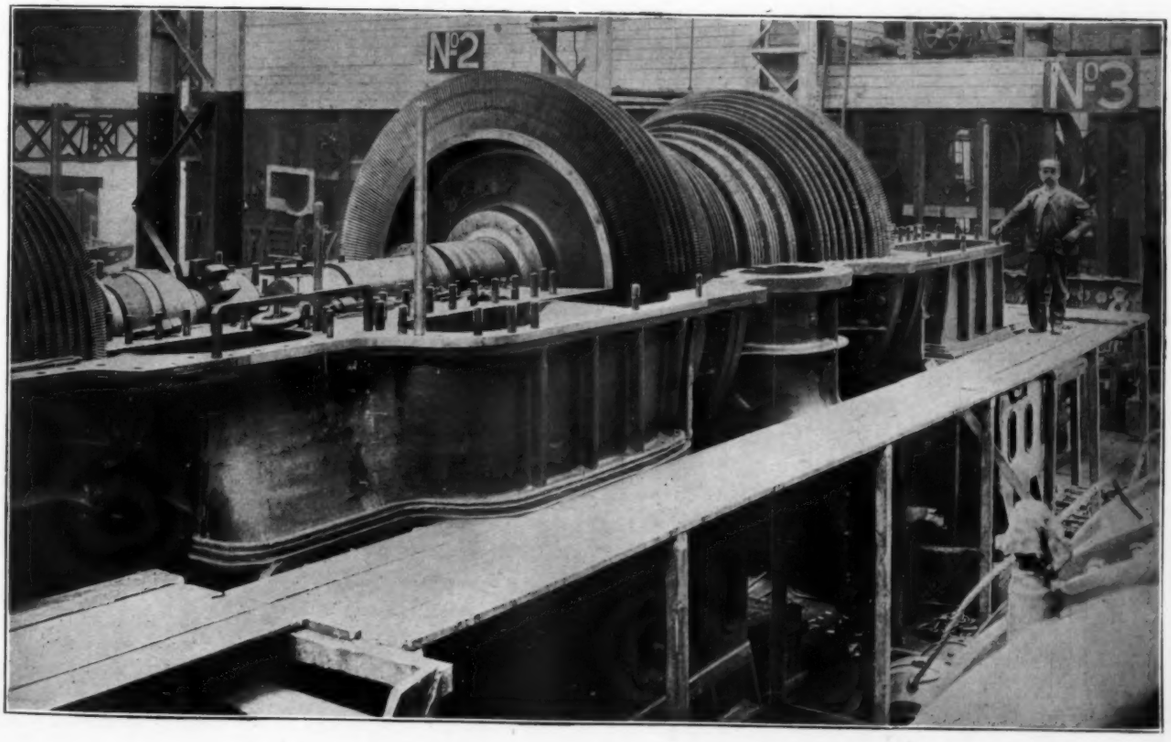


Fig. 9.

(*To face page* 464.)

15,000-KW. THREE-PHASE TURBO-ALTERN

CONSTRUCTED BY MESSRS. C. A. PARSONS AND C

(For Descri

Fig. 1.

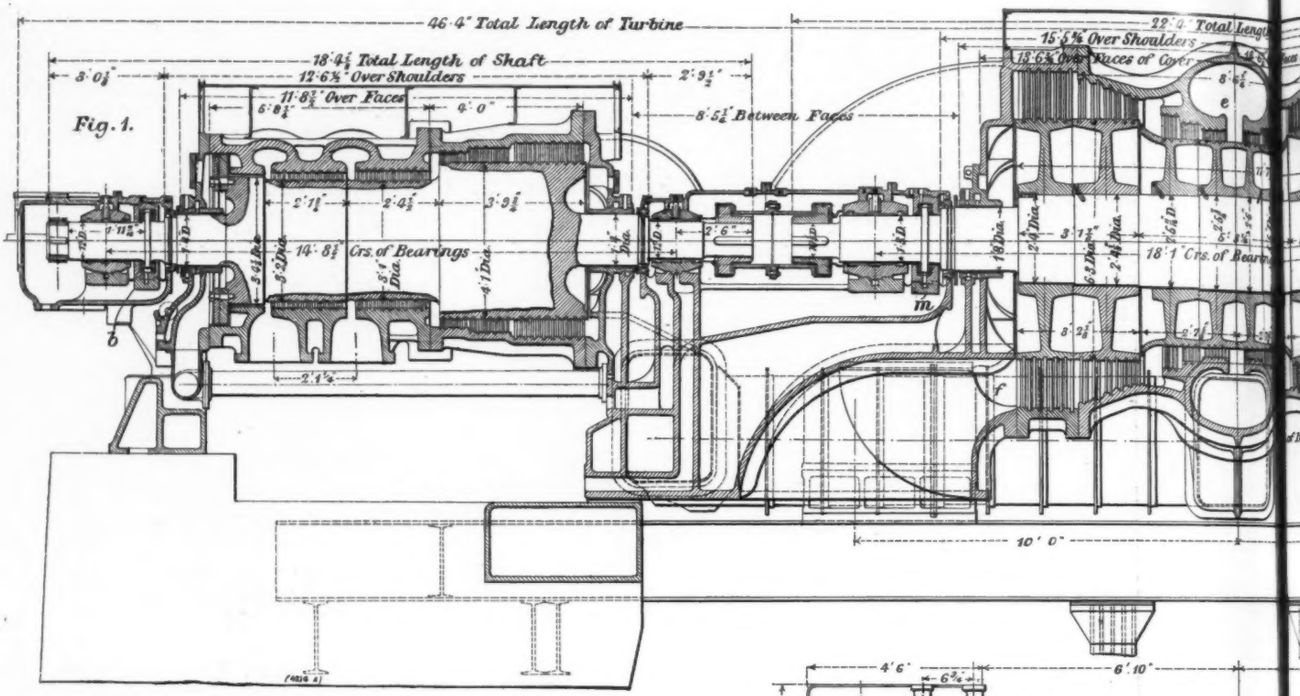


Fig. 2.

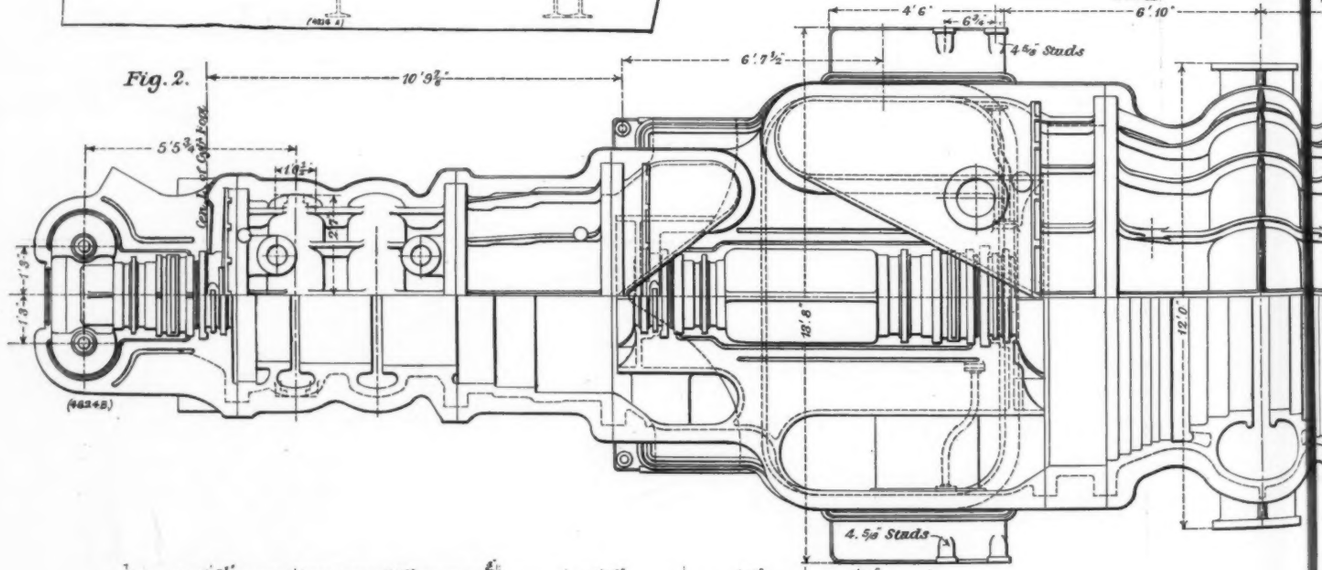


Fig. 3.

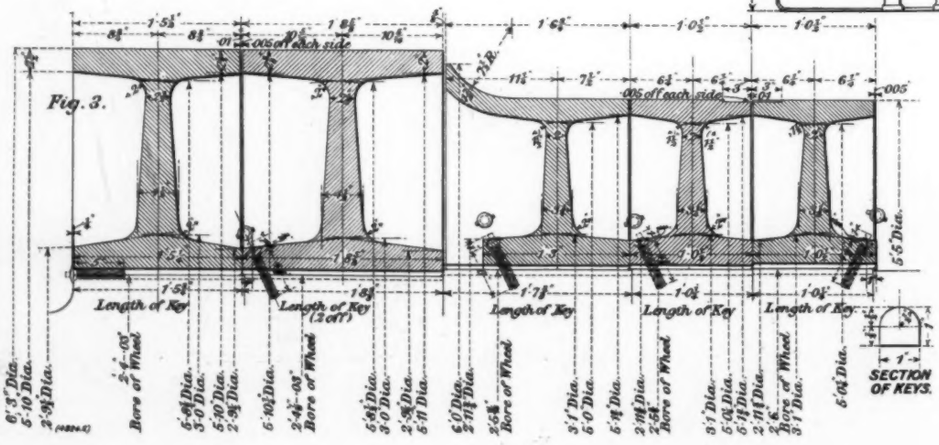


Fig. 4.

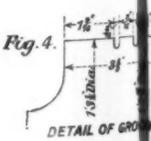
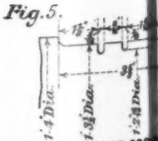


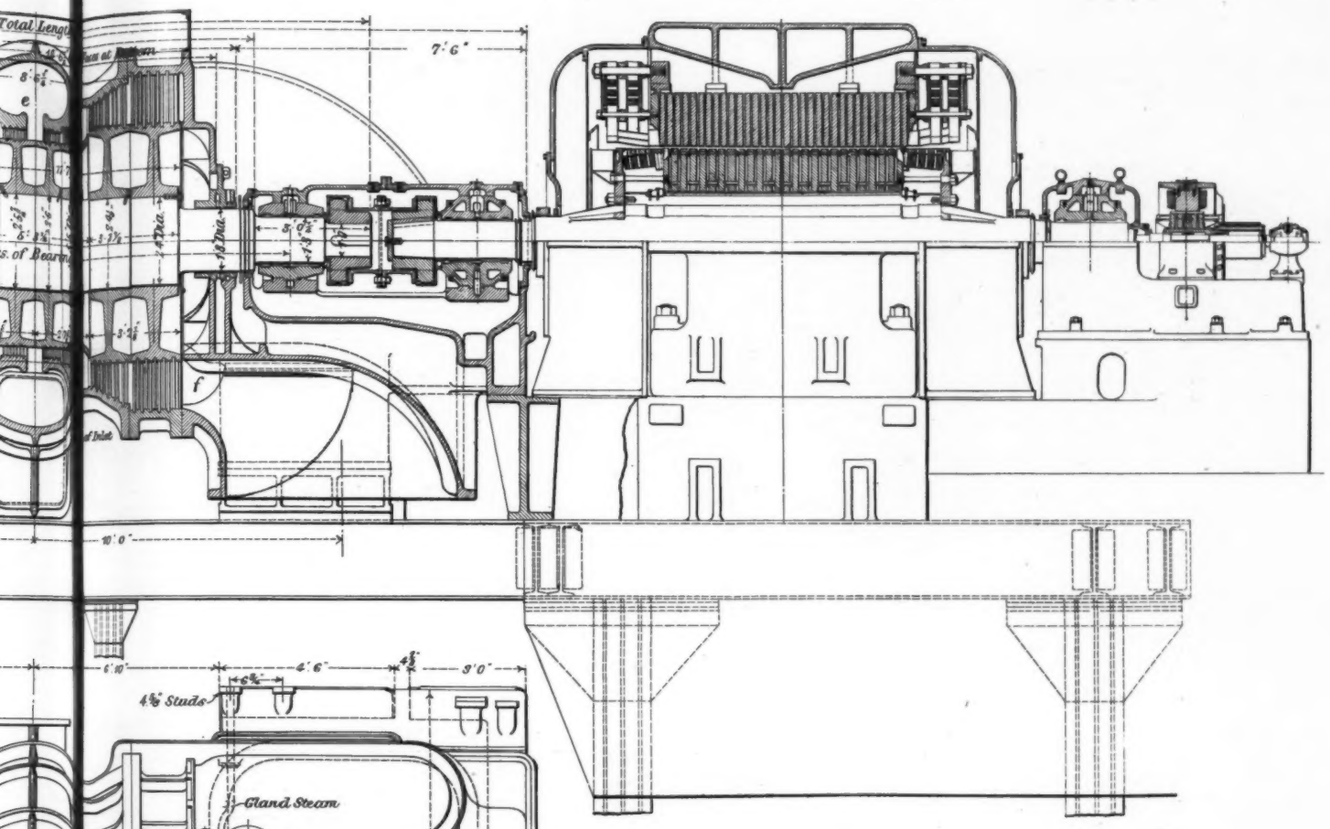
Fig. 5.



TERNATOR FOR LOTS-ROAD POWER STATION.

S AND (LIMITED, ENGINEERS, HEATON, NEWCASTLE-ON-TYNE.

(For Description see Page 465.)



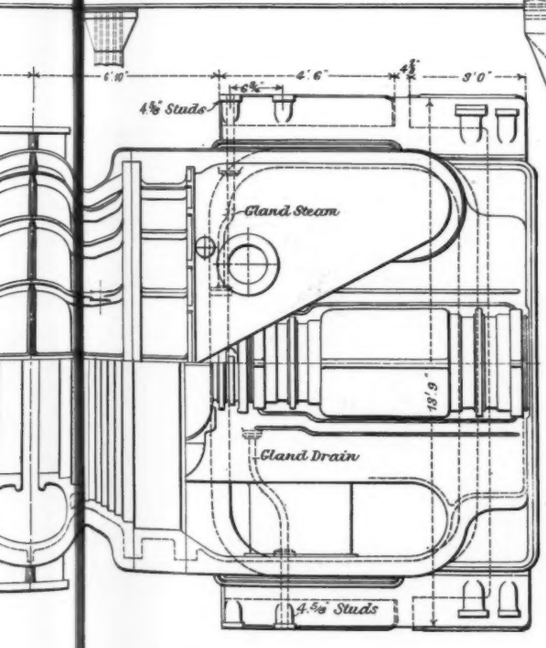
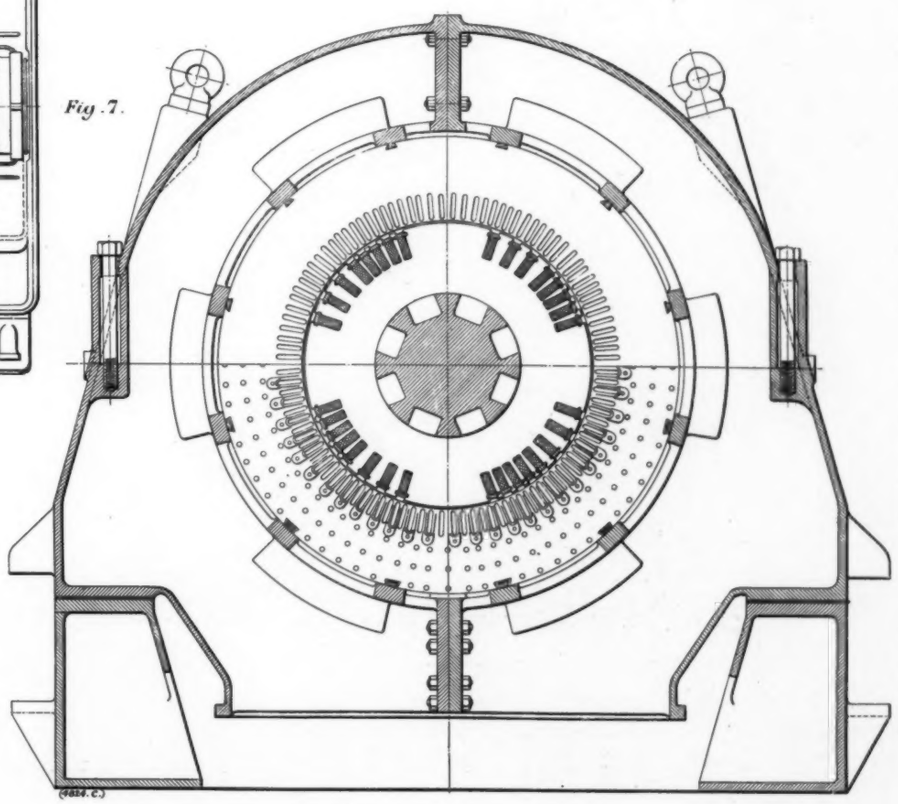


Fig. 7.



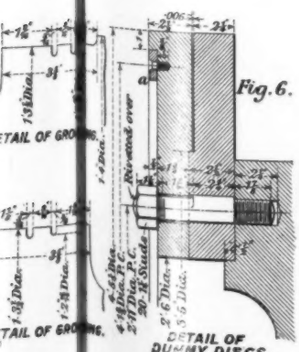


Fig. 6.

(3834.C.)

15,000-KW. TURBO-ALTERNATOR FOR LOTS-ROAD POWER STATION.

CONSTRUCTED BY MESSRS. C. A. PARSONS AND CO., LIMITED, ENGINEERS, HEATON, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 465.)

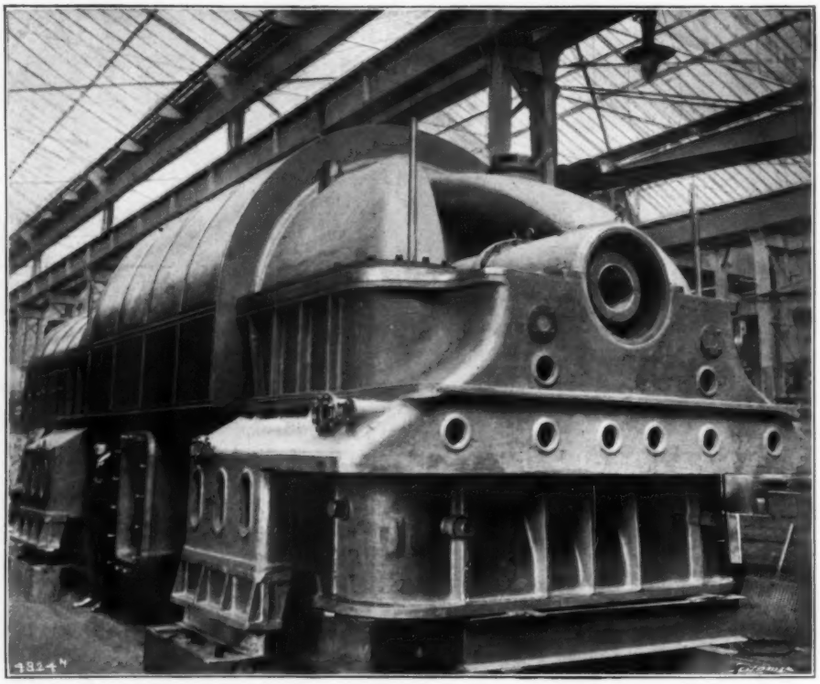


Fig. 10.

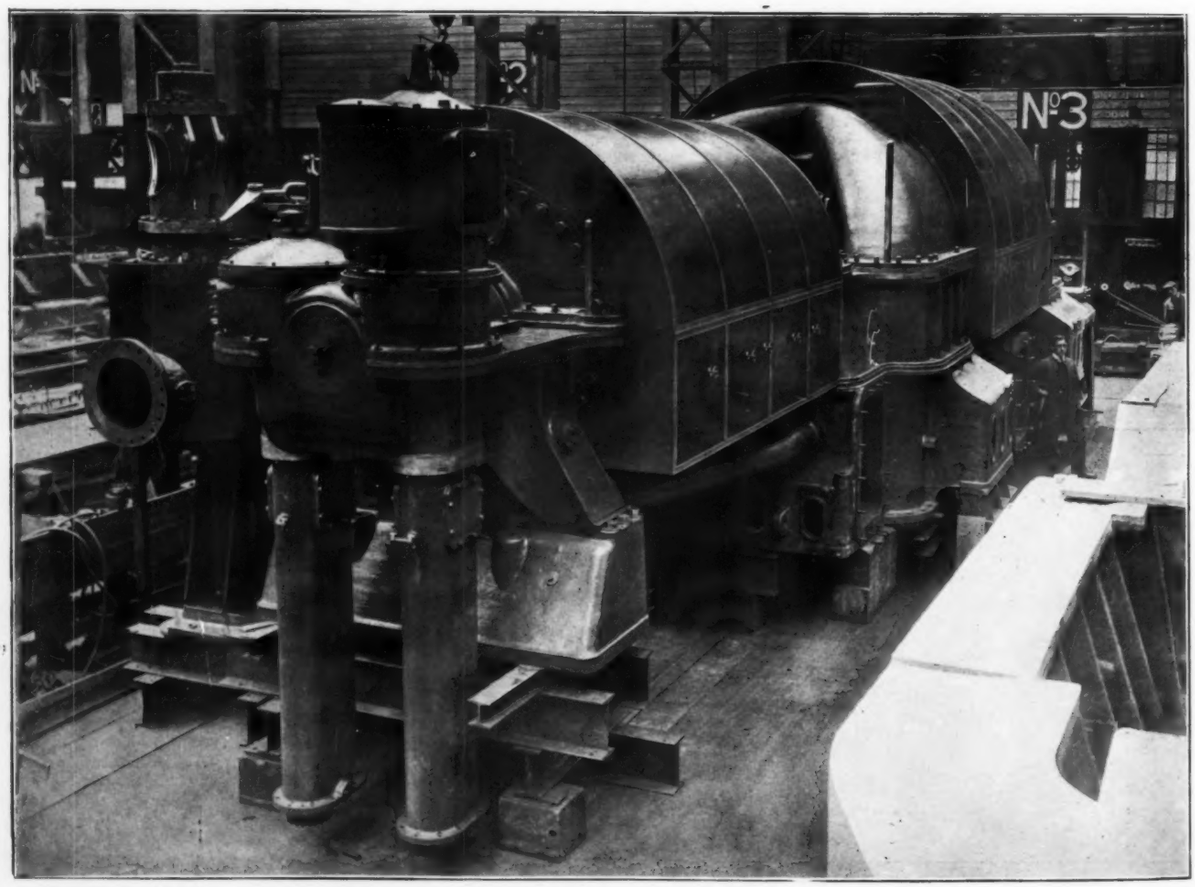


Fig. 11.

(*To face page* 465.)

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 18, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper:—"The Construction of Turbine Pumps," by Mr. A. E. L. Chorlton, Member, of Lincoln.

THE CERAMIC SOCIETY: THE REFRACTORY MATERIALS SECTION.—Monday, May 21, at 2.30 p.m., in the Music Room, Theatre Road, Stourbridge. Chairman, Major H. C. King. The following papers will be read:—"The Clays of South Staffs and its Borders," by Dr. W. S. Boulton, the University, Birmingham. "The Scientific Management of Brick Works," by Major C. W. Thomas, Stourbridge. "Fireclay from a Manufacturer's Point of View," by Mr. G. H. Timmis, Stourbridge. "Refractories and Modern Kilns," by Mr. J. G. Maxwell, Gas-Fired Kiln Company, London. "Refractories for Steel Furnaces from the Consumer's Point of View," by Mr. W. J. Brooks, Shelton Steel and Iron Company, Stoke-on-Trent. At 8.15 p.m. Popular Evening Lecture.—"Black Cores in Bricks," by Dr. J. W. Mellor, Stoke-on-Trent.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, May 23, at 2.30 p.m., at the Midland Hotel, St. Pancras. The paper on "Automatic Signalling," by Mr. C. H. Ellison, will be further discussed.

THE AERONAUTICAL INSTITUTE OF GREAT BRITAIN.—Thursday, May 24, at 8 p.m., in the Central Hall, Westminster. A paper on "The Testing of Materials for Aeronautical Construction" will be read by Mr. Edgar A. Allcut, M.Sc., A.M.Inst.C.E., A.M.I.Mech.E., of Messrs. W. and T. Avery, Limited, Birmingham. Visitors will be welcomed.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, May 24, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. The following paper will be discussed:—"Shall Great Britain and America adopt the Metric System?" by Mr. Walter Renton Ingalls, Member, President, Mining and Metallurgical Society of America, President, American Institute of Weights and Measures."

THE PHYSICAL SOCIETY OF LONDON.—Friday, May 25, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda:—(1) "An Investigation of Radium Luminous Compound," by Mr. C. C. Paterson, Mr. J. W. T. Walsh and Mr. W. F. Higgins. (2) "The Resistance to the Motion of a Lamina, Cylinder or Sphere in a Rarefied Gas," by Mr. F. J. W. Whipple. (3) "The Effect of Stretching on the Thermal and Electrical Conductivities of Wires," by Dr. C. H. Lees, D.Sc., F.R.S.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 25, at 5.30 p.m. A discourse will be delivered by Mr. J. Barcroft, M.A., F.R.S. The subject is "Breathlessness." Afternoon lectures next week at 3 p.m. Tuesday, May 22. Professor D'Arcy W. Thompson, C.B., D.Litt., F.R.S., Professor of Natural History, Dundee, on "Architectural Design in Organisms—the Laws of Growth and Form" (Lecture II). Thursday, May 24. Professor William Bateson, M.A., D.Sc., F.R.S., on "The Chromosome Theory of Heredity and the Alternatives" (Lecture II). Saturday, May 26. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "The Electrical Properties of Gases" (Lecture IV).

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, LONDON, INCORPORATED.—Saturday, May 26, at 2.30 p.m., at Caxton Hall, Westminster. Continuation of discussion on paper on "The Locomotive Designer and Design."

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MAY 18, 1917.

THE ENDOWMENT OF RESEARCH IN AMERICA.

WE are at last doing something for promoting scientific research in this country, but very few people have any idea of the sums required for the purpose. The Government has allocated a million sterling, which is an immense amount of money in comparison with such grants in the past, but it is certain that many further demands will have to be met. When the School Boards were introduced in 1870 we were told a rate of threepence or fourpence in the pound would cover every conceivable cost, but since then we have seen the rate at fifteen pence, in addition to millions voted directly by Parliament. The public has been gradually educated as to the necessity of teaching all the proletariat the three R's, and then of continuing the instruction of those who are capable of going further in science, literature or art. In a similar way we trust that they will gradually come to appreciate the national importance of the diffusion of a knowledge of science among our manufacturers and also among our governing classes. This, however, is not a matter that can be pursued "on the cheap," for it has to be done in competition with Germany and America. In the latter country the endowment of education—scientific, technical and literary—has been on a most lavish scale, and although the results have not always seemed to justify the expenditure, yet a solid foundation has been laid and greater fruition may be attained in the future. In 1914 the agricultural colleges of the United States had endowment and land-grant funds of the value of 12,000,000*l.*, buildings valued at 10,000,000*l.*, farms and grounds of nearly 5,000,000*l.*, and plant of one kind and another bringing the total value of property up to 32,000,000*l.* The income was nearly 7,000,000*l.*, the number of instructors 6,370, and the number of students 69,132. This means that there was about 4,500*l.* of capital per student, and 100*l.* of annual income. Now, little more than half the students were of the college and graduate class, the remainder being preparatory and short and summer course students. Clearly the funds are far in excess of what is necessary for the students, and very much of them must be devoted to research work in agriculture.

There is in the United States a Department of Agriculture, founded in 1882, which, however, has a wide range of duties, for it includes the Weather Bureau and the Forest Service, and the enforcement of a number of regulating laws, including those relating to meat inspection, animal and plant quarantine, food and drugs, game and migratory birds, seed adulteration, insecticides and fungicides, and vaccines and viruses. In 1915 the expenditure was 5,330,000*l.* There are about 15,000 employees, of whom 2,000 are engaged in scientific investigations and research, 1,400 in demonstration and extension work, and 2,700 in administrative and supervising work. This Department is, of course, quite distinct from the agricultural colleges referred to above. These latter derive their funds under the Morrill Act, 1862, which is administered by the Bureau of Education of the Department of the Interior, the Hatch Act, 1887, and the Adams Act, 1906, for the promotion of research work by the establishment of State experiment stations, and the Smith Lever Act, 1914, under which provision is made for extension work, that is, the dissemination of information. The Experimental Stations are established under the direction of the colleges, and cover the whole range of the physiology and pathology of plants and animals germane to farming. They are, however, affiliated to the Department of Agriculture, which makes them grants additional to the income already set forth. There are 52 stations, which receive grants under two Acts, the total amount annually granted being 285,000*l.* The annual revenue of these stations is 740,000*l.*, including 515,000*l.* from the State Governments, making a total revenue of 1,025,000*l.*

In addition each State undertakes agricultural extension work in co-operation with the Federal Department of Agriculture. A sum of 2,000*l.* per annum is granted by each State, and in addition a sum beginning at 120,000*l.* in 1914, and increasing over a period of seven years to 820,000*l.* per annum, is allotted on a rural population basis by the Secretary of Agriculture. The extension work includes (*a*) farm demonstrations, (*b*) county agricultural agents, (*c*) boys' and girls' club work, (*d*) girls' demonstration work, (*e*) home economics extension work, (*f*) the extension work of the State Agricultural Colleges and Federal Departmental experts, (*g*) movable schools, and (*h*) publications.

In considering these large sums it must be remembered that the United States cover an immense area, with every variety of climate from sub-tropical to sub-arctic, and with all kinds of soil. There is space and need for countless experiments, many of them on an enormous scale, and hence vast expenditure is necessary and will be repaid. Still these figures, which we take from a most illuminative report written by Mr. Gerald Lightfoot, M.A., F.S.S., Acting-Secretary to the Executive Committee of the Commonwealth Advisory Council of Science and Industry, Melbourne, must present a serious aspect to the statesmen of Australia, with its immense areas and its relatively small resources. Not for many years can they hope to equal them, and

possibly never unless they follow the prudent policy of the States, which long ago assigned large blocks of land for the purpose of raising funds for educational purposes. The Morrill Act, 1862, granted to each State an area of 30,000 acres for each Senator and Representative in Congress to which the States were respectively entitled, to form a fund for the endowment and support of at least one college where the leading object should be to teach such branches of learning as are related to agriculture and the mechanic arts. There have been other grants since, but the land grants account for a large part of the immense capital and income we have referred to. It certainly seems a most justifiable policy to devote a part of the public lands to find means for properly utilising the remainder.

The care of the Government of the United States for the produce of the land does not stop at agriculture, but it also includes forestry. One-fourth of the total area of the States, that is 550,000,000 acres, is covered with forest, and of this 200,000,000 have been set apart as reserves under the administration of the Forest Service of the Department of Agriculture. The annual expenditure for administration and protection is 950,000*l.*, the expenditure on permanent improvements 120,000*l.*, and the total receipts 490,000*l.* There are 29 Government nurseries, which supply the national forests. These have a present stock of 34,000,000 plants, and can supply 15,000,000 plants a year. Detailed investigations of important problems are conducted at eight thoroughly equipped forest experiment stations. There is a forest laboratory at Madison, which has cost 50,000*l.*, with an annual appropriation of 42,000*l.* In addition 32 States have Forest Departments of their own for the education of public sentiment regarding forests, for providing expert advice to private owners, for the development of a fire protective system, for the provision of planting stock, and other objects.

The endowment of research in the United States is not confined to questions germane to agriculture and forestry. The Bureau of Standards is familiar to all our readers, but it is on a very small scale in comparison with the establishments we have been considering. The laboratory grounds cover an area of 16 acres, the cost was about 200,000*l.*, and that of the equipment 85,000*l.* The annual expenditure is 125,000*l.* The Bureau of Mines has an annual expenditure of 6,500*l.*, but large sums are contributed by corporations and institutions interested in investigation work. There must, however, be further expenditure for publications, for the bulletins we receive from this Bureau represent a very large sum annually. The Public Health Service is a branch of the Treasury, and has an annual expenditure of about 600,000*l.*, with a total staff of 2,000. The Smithsonian Institution, Washington, is "an establishment for the increase and diffusion of knowledge among men." It takes the whole world for its field, and in addition has the administrative charge of the National Museum, the International Exchange Service, the Bureau of American Ethnology, the National Zoological Park, the Astrophysical Observatory, the Langley Aerodynamical Laboratory, and the United States Regional Bureau for the International Catalogue of Scientific Literature.

In addition to the Federal institutions there are many maintained by the States, which do a large amount of research work. There are important universities of Minnesota, Michigan, Columbia, and Wisconsin, not to mention others. Also Harvard University and the Massachusetts Institute of Technology. There are engineering experimental stations at several of the universities, chief among which is that of the Illinois University. Many of its researches have been reported in our columns.

The millionaires of America have in many instances given princely donations to scientific institutions. Mr. Andrew Carnegie founded the Carnegie Institute of Washington with an endowment of 2,000,000*l.*, to which he added later 2,400,000*l.* This institution has eleven large departments of research, besides many minor ones. Mr. J. D. Rockefeller provided 40,000*l.* a year for the institute which bears his name, and is devoted to medical research. By 1907 the endowments reached a total of 700,000*l.* for land and buildings and equipment, and a fund of 2,100,000*l.* for maintenance. In addition 200,000*l.* has been given for a department of animal pathology, and 100,000*l.* for a pension fund, besides other sums. Sir Robert Ball, after his last visit to the States in 1902, wrote to a friend*:—"The wealth that is pouring into the universities all over the country is one of the consequences [of the millionaires]. Many times during my stay did the universities announce the receipt of millions. President Harper, of Chicago University, declared that he intended to collect 10,000,000*l.* for Chicago, and he is in a fair way to do it. In these universities it is not alone the superb equipment and the wealthy endowment which strike me as admirable. I was still more astonished at the high degree of the education given . . . The professors of mathematics are in the very forefront of the science. . . . There are two high-class mathematical journals in America. It is doubtful if there is one in Great Britain to which the same description can be applied." It will be remembered that Sir Robert was a distinguished mathematician, and that in addition to his astronomical work he filled professorial chairs at Trinity College, Dublin, and at Cambridge, so he was competent to pronounce judgment.

To refer to all the institutions in the United States devoted more or less to research would require far more space than we can spare, and would be of little interest. Enough has been done to show that an immense capital has been allotted in America to education and research, and that we shall have to reckon with this if we are to hold our position in the scientific world. We can never hope to attain to similar sums, but that is not needed. As we have set forth, the bulk of the money now available in America is devoted to agricultural problems, which are enormously more complex there than here, and represent a greater proportion of the national assets. Still a great deal remains when that is subtracted, and it will need all our exertions to keep level with our competitors. In pure science we have always held our own, in spite of the scant encouragement of the State, but it is in applied science that we are behindhand. This war has shown us how far we are dependent on other nations for manufactures that demand deep scientific knowledge, and it is in this respect that we need to enlarge our resources very greatly. Fortunately there is no very direct connection between endowment and results; an energetic, capable Director is a better acquisition than 100,000*l.*

* "Reminiscences and Letters of Sir Robert Ball." Edited by his son, W. Valentine Ball. London: Cassell and Co., Limited.

THE ELECTRICAL PROPERTIES OF GASES.

On Saturday afternoon last Sir J. J. Thomson, O.M., P.R.S., delivered at the Royal Institution the second lecture of his course on the above subject. In his opening remarks Sir Joseph Thomson observed that in his last lecture he had given reasons for concluding that when a gas conducted electricity, this electricity was carried by charged particles. In this respect the phenomenon resembled that of electrolysis, as to which the ordinary view was the current was conveyed by positively charged particles, such as hydrogen atoms, moving in one direction through the liquid, and by negatively charged particles going the opposite way; the mechanism at work, therefore, was very analogous to that which, we were led to believe, was responsible for the passage of a current through a gas. The phenomena in the latter case was, however, characterised by some strange features not normally exhibited in electrolysis. In the first place, an increase in the thickness of the slab of gas through which the current passed gave an increase of current, whilst with electrolytes such an increase of thickness enfeebled the current, and in this respect the behaviour of a gas was at variance with the known behaviour of electrolytes. Moreover, with the latter the effect of doubling the potential difference responsible for the flow was to double the current. With a gas, on the other hand, up to a certain stage there might be very great differences in the voltage drop without materially affecting the strength of the current, which, after a certain potential difference was reached, became practically constant. The reason for this peculiarity of gases lay in the fact that the number of carriers available for conveying the electricity from one electrode to the other was small, whilst in a liquid electrolyte the number was practically unlimited. In the gas not more than one molecule in a million millions was ionised, whilst in the case of a liquid electrolyte the number of ions was an appreciable fraction of the whole number of molecules present.

As an analogy he might observe that in the transport of troops it was useless marching up men to a railway station in greater numbers than the trains available for taking them away could carry. The rate of transport to the other end would be limited by the train service available, and until this limit was reached the number carried over the rails would be governed by the rate at which the troops reached the station. When this rate equalled that for which carriage could be provided, no further crowding up the station would increase the number transmitted to the further end of the line. In the case of a gas conducting electricity a point was soon reached at which the whole of the carriers available were used up, thus fixing a limit to the strength of the current, whilst in normal electrolysis there was practically an unlimited supply of carriers, and the current accordingly increased proportionately to the potential difference. Some liquids were, however, very bad conductors, and with these a stage was reached, just as with gases, in which an alteration in the potential difference had no effect on the current, so few carriers being available that a comparatively small current used them all up.

He had dwelt on this point, Sir Joseph continued, because this difference in the behaviour of a conducting gas and a normal electrolyte had long been urged as a difficulty in accepting the idea that the current was carried through a gas by means of charged particles. It would be seen, however, that the explanation was perfectly simple, the special features of the flow being a mere matter of the number of carriers available.

In general, whether a gas were rendered conductive by the action of radium, by Röntgen rays, or other agents, the conductivity was very small. By applying to such a gas a suitable electric field it was, however, possible to make each charged particle "breed"—becoming thus the ancestor of a very numerous family. Under such conditions we might, in fact, get from the original particle a million of descendants. Suppose, for example, that we had two parallel plates, the one charged positively and the other negatively, with a conducting gas between. Each negative particle in the 'tween space would be pushed along from the negative plate towards the positive one, and its speed would depend on the force applied. So long as it moved slowly it passed through the gas without splitting up the molecules encountered. If, however, it moved above a certain pace, or, rather, with more than a certain amount of energy, it would, on encountering a molecule, split it up into a negative particle and a positive one. The negative particle thus freed would also be pushed along like its progenitor, and when, under the action of the field, it acquired a sufficient speed, it would in its turn ionise another molecule. Each negative particle thus set free became accordingly the parent of two charged particles, and hence, before the original particle had moved very far, the total number of charged particles present would be increased to a very large extent.

Hence, when the potential between the two parallel plates was steadily increased, starting from a low value, a stage was at length reached at which the current increased with very great rapidity. The change came in quite sharply, and the gas suddenly became quite a good conductor, comparable with the best solution of sulphuric acid in water. This the lecturer demonstrated by showing that the energy absorbed by an exhausted bulb (containing a little residual gas) placed within a coil which was traversed by a very rapidly alternating current was as great as if the bulb had contained a mixture of sulphuric acid and water.

In experiments of this kind, the lecturer proceeded, although the gas showed very considerable conductivity, there was no indication of any

approach to an unstable state. Nothing, in fact, comparable to what happened on the discharge of a Leyden jar. The discharge through the gas was quite orderly, and not comparable in intensity with the discharge of a jar, or of a lightning flash. The difference was due to the fact that in the orderly discharge in the bulb the negative particles alone acquired sufficient energy to ionise the molecules of the gas passed through. The current, it was true, increased rapidly, but this increase was finite, depending on the distance between the plates and the number of negative particles produced by the original ionising agent. Matters became different if, in addition to the negative particles producing fresh ions, the positive particles also began to ionise the gas.

So long as the negative particles were alone able to split up molecules, the whole of the negative particles, parent and progeny, were chased along to the positive plate, where the whole were finally got rid of. If, however, the positive particles also began to ionise the gas, these, as they moved towards the negative plate, liberated fresh negative particles behind the original ones, and everything began over again, with the difference that the supply of negative particles available for ionisation was greater than that at the start, and would continue to increase indefinitely. An enormous current could thus be built up, starting at the outset with but one or two charged particles. Two stages could, then, be recognised—one in which the negative particles alone acted as ionisers, and a second stage in which the positive particles also acquired sufficient energy to act.

A similar condition might also, the lecturer said, be produced in other ways. What was necessary was that fresh negative ions should be liberated near the negative plate. The Röntgen rays produced by the striking of the negative particles against the anti-cathode could therefore serve, generating fresh ions near the negative plate and producing an instability in which the current mounted up to an enormous value.

The most conspicuous example, and the most important, of this kind of discharge was afforded by the lightning flash. Although lightning was the oldest electrical phenomenon known, there was, until very recently, Sir Joseph said, not much precise information about it. Indeed, it was only within the past four or five years that we had any reliable measure of the amount of electricity which passed in a flash or any reliable estimate of the length of the flash. Nothing was known, moreover, as to whether the discharge carried to the earth a positive or a negative charge. There had, however, been a great number of general observations on lightning and its associated phenomena. A great number of these reports were difficult to believe, but amongst these the lecturer did not, he said, include statements as to balls of fire running about the ground and finally exploding with a sulphurous smell.

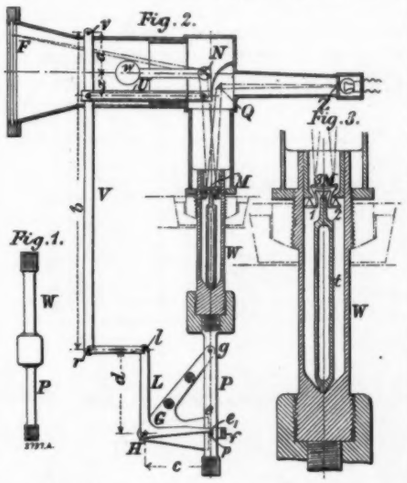
The researches of Mr. C. E. T. Wilson at Cambridge had, he proceeded, given us some definite measurements as to the order of the quantities with which we had to do in a lightning discharge. Fortunately, or unfortunately, England was not a very good place for the study of lightning. Mexico, where thunderstorms occurred daily, would be better. In England they were sporadic, and it commonly happened that when the storm occurred the would-be observer had not got his instruments ready. Mr. Wilson had, however, made a systematic study of the matter. His plan of procedure consisted in installing recording instruments at two stations some considerable distance apart. The charged thunder-cloud produced at places in its neighbourhood an electric force, the intensity of which was recorded by the instruments at the two stations. If the cloud discharged, the part of the force due to this loss of electricity disappeared and the instruments recorded a kink, the magnitude of which differed at the two stations. Its size depended upon only two variables, viz., the quantity of electricity discharged and the distance of the cloud from the station. Hence the two simultaneous observations served to determine both the quantity of electricity passed and the height of the cloud, that was to say, the length of the flash. In this way Wilson found that the length of an ordinary flash was 10 km., or about 6 miles, whilst the quantity of electricity passed was about 30 coulombs. He further found that even at his stations, which were not immediately under the flash, the increase of potential was at the rate of 2,000 volts per metre of vertical height, and it was no doubt much greater immediately in the line of the discharge. Taking this value as a minimum, the actual value of the potential difference between the cloud and the earth at the moment the spark passed was therefore 20,000,000 volts. Hence, as the electricity passed was 30 coulombs, the energy expended was 6×10^{10} ergs, or about 600,000 ton-metres. It was not surprising, therefore, that lightning flashes were so destructive; it was, in fact, rather remarkable that they did so little damage. Fortunately the greater part of their energy was not spent in destructive purposes.

Thunder, the lecturer proceeded, was due to an impulsive wave produced all along the track of a flash. This was, he added, apparent with even a comparatively short spark, as he demonstrated with an apparatus consisting of a bulb containing air and provided with a water-gauge of fine bore. On discharging a spark through the bulb a wave of high pressure was produced, which was indicated by the motion of the water in the gauge. Lightning, he stated, produced the same effect, but on an infinitely greater scale.

AUTOGRAPHIC LOAD-EXTENSION DIAGRAMS.

THE May lecture to the Institute of Metals was this year delivered by Professor W. E. Dalby, F.R.S., and described "Researches made possible by the Autographic Load-Extension Indicator."

Professor Dalby opened his lecture with a description of the instrument used in his researches. This has already been fully described and illustrated in our columns. It will suffice, therefore, to recall its



essential features, and to this end we reproduce from our issue of ENGINEERING, June 7, 1912, Figs. 1, 2 and 3. In Fig. 1, P denotes the specimen under test and W a calibrated steel bar coupled to the specimen as indicated, so that both are, during the test, under the same pull. The amount of this pull is measured by the stretch of the bar W, which serves, in fact, as a very accurate spring balance. Since, however, the total extension of W under the maximum pull it is intended to transmit is only about $\frac{1}{100}$ in., a large magnification is necessary in order to get a sufficiently open scale.

In Professor Dalby's apparatus the magnification is effected optically, thus obviating the possibility of inertia errors. As best seen in Fig. 3 the weighbar W is hollow, and at its upper end has mounted on it a box, as shown. Within this box is, at Z, a point source of light. The ray from Z, after reflection at the fixed mirror Q, passes on to the concave mirror M, which reflects it on to third mirror at N, and thence to a photographic plate at F, on which it is accurately brought to focus.

The mirror M is, it will be seen, supported on three points, two of which form a fulcrum about which the mirror can tilt, whilst the third rests on a cup on the top of the central rod shown. Any stretch of the bar W will thus tilt the mirror M, and this tilt will cause the point F to move horizontally across the photographic plate. The displacement at F is 340 times as great as the stretch of the bar W. A system of linkwork, shown to the left of Fig. 2, causes the mirror N to rotate proportionately to the stretch of the specimen, and this movement displaces the point F vertically up and down the photographic plate. Hence the point of light traces on the plate the stress-strain diagram of the test made. From this plate, after development, both the load and the corresponding extension of the specimen can be measured with the greatest accuracy. The scale for both is easily determined. It will be seen that the apparatus is complete in itself. Any machine with which a specimen can be pulled in two can be used as a testing machine. The calibrated bar gives the load more accurately than most testing machines could do, as the reading is not liable to errors from inertia or from knife-edge friction. The diagrams are quite free from distortion and record the load quite accurately right up to the moment of fracture. When this occurs, the spot of light shoots back so rapidly that it fails to leave any trace on the plate, and the diagram terminates abruptly at the moment of fracture. It is, moreover, possible to determine, with precision, from the diagrams the stretch corresponding to the maximum load carried, a matter which is of importance in estimating the plasticity of a bar.

In his lecture Professor Dalby stated that the diagrams were so true and consistent that it was possible to fix, on examining one to which bar out of a batch it referred, and also to say a good deal as to the previous history of the bar. In fact the plastic portion of the curve was what characterised a metal, and by studying a diagram for Yorkshire iron it was possible to name the works from which it came.

There was a great difference, the lecturer said, between the diagrams furnished by iron and steel and by the non-ferrous metals. All the non-ferrous metals gave a continuous diagram with no break at the junction of the elastic and plastic portions of the complete curve. This was well shown by the copper diagram reproduced in Fig. 4, page 480. Copper, Professor Dalby said, was a very peculiar metal. It might be treated in all manner of ways without affecting to any material extent the shape of the diagram recorded. It might, after heating up, be cooled slowly in lime or rapidly in water, but the effect on the diagram was so small that it was difficult to say whether it was due to the difference in the treatment or to differences in specimens cut from the same bar. Arsenical copper gave a diagram differing very little from that yielded by electrolytic copper. With brass, on the other hand, a difference in the past history of the metal had a large effect on the stress-strain diagram, as was well shown in Figs. 5, 6 and 7, page 480. A peculiarity of brass was that the plastic line in the neighbourhood of the breaking-point always showed a little crinkling effect. This was characteristic of the metal, and appeared on each of the three diagrams relating to brass, in spite of the effects of annealing shown by Figs. 6 and 7.

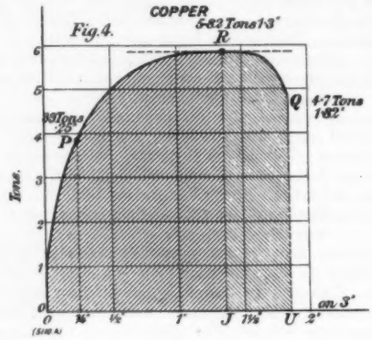
Phosphor bronze, the lecturer proceeded, always gave a curve resembling a scythe standing on its handle, but the elastic portion of the curve, Fig. 8, resembled that for rolled brass. Characteristic curves for tin, gun-metal and zinc were reproduced in Figs. 9, 10 and 12, whilst Fig. 11 was obtained in testing a light but strong aluminium alloy, which gave, it would be seen, quite a good curve, the shape of which was peculiar to the metal. With zinc the load fell steadily during the plastic stage, and the metal broke much below the maximum load carried.

A group of curves for iron was, he continued, represented in Figs. 13 to 17. In Fig. 13 the common quality of the iron was indicated by the small extension after the attainment of maximum load. The Staffordshire iron from which Fig. 14 was obtained was better, and the Yorkshire iron better still, the plastic portions of the curve being fuller. One, it would be seen, showed a longer

break at the yield-point and a flatter plastic curve subsequently than the other, and the difference was characteristic of the two brands. A piece of the very best Swedish iron was responsible for Fig. 17. The large extent to which it drew out before fracture was very noticeable. Cast-iron gave the diagram reproduced in Fig. 18, which showed no plastic extension. The diagrams Figs. 19 to 22 were yielded by mild steels with carbon content ranging from 0.1 per cent. in the case of Fig. 19 to 0.4 per cent. in that of Fig. 22. The extra-soft metal gave a curve very like that obtained from iron, but there was a longer break at yield. In Fig. 20 the notable feature was the numerous attempts the metal made to build up its plastic curve before it finally succeeded. With still harder steels, the lecturer added, there was evidence of a mechanical discontinuity in the properties near the eutectic composition. With alloy steels the break at yield disappeared, and the curves had the same character in this respect as those of the non-ferrous metals. This was clearly shown in Fig. 23. The plastic curve for manganese steel showed that the metal yielded in a series of steps and, as would be seen, it broke off short without local contraction. The nickel-chrome steel represented was of very fine quality, carrying 54 tons before the plastic stage was reached. it then drew out and broke like a soft carbon steel. Considering the three curves represented in Fig. 23, it would seem that these alloy steels belonged to a family in which the strength increased as the ultimate extension diminished.

Professor Dalby said he would next discuss the question of ductility. This, he said, was generally estimated from the total plastic extension of the specimen. The figures thus obtained were, however, not generally comparable. This would be clear on reference to Fig. 24. In this a specimen was represented at different stages during a test. Five gauge points were marked off as indicated at A. At B the specimen was shown at about the period when the maximum load was attained. This had produced a permanent set, but, as shown by the diagram on the right, each inch had stretched equally.

Fig. 4.



In the succeeding stages this was no longer the case, so that the total extension on fracture was compounded of two terms, viz., a general uniform extension of the specimen as a whole and a much greater local extension in the neighbourhood of the break. This compound effect could be represented by a formula including two terms.

In a paper read before the Institution of Civil Engineers in 1903 Professor Unwin had remarked that "The difficulty of comparing the elongations of different test bars would probably disappear if the general elongation, or elongation at maximum load, were taken as the measure of ductility, and this has sometimes been proposed. But there is no way hitherto known for obtaining the general elongation except by taking an autographic load-strain diagram." With the diagrams yielded by his apparatus there was, Professor Dalby said, no difficulty in obtaining the extension at maximum load. The plate was placed over a special desk with a glass top, and lighted from below, and the point at which the tangent to the plastic curve became horizontal was then readily determined as indicated in Fig. 4. In the case of the common iron, to which Fig. 13 referred, the extension up to maximum load was 18 per cent., and the total elongation 22 per cent. Corresponding figures for one of the Yorkshire irons were 22 per cent. and 28 per cent. respectively.

The true law of comparison for different specimens had, the speaker continued, been laid down by Barba in 1808, who stated that to be comparable tests should be made on geometrically similar specimens. This implied the use of one shape of standard bar only, which was impracticable; but a fair compromise was to take the gauge length as proportional to the square root of the area of the specimen, say at 10 diameters for a round specimen. This was not always easy to do, and in many cases short specimens were all that could be obtained. In order to obtain a basis of comparison between short and long specimens the speaker had, he said, made a series of tests on a number of specimens cut from the same bar, but with varying distances between the shoulders, the range covered being from $\frac{1}{8}$ in. up to 5 in. The whole series of curves obtained were plotted *en echelon* in Fig. 25. A noticeable point was that the irregularity at yield increased with the length between shoulders and almost disappeared when this distance was reduced to $\frac{1}{8}$ in. For the purpose of comparison further tests were made on a long bar, the extension being

Fig. 5.

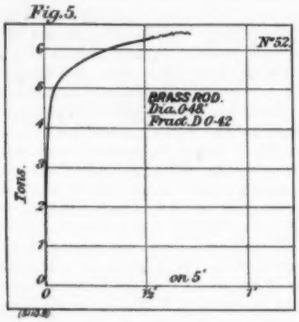


Fig. 6.

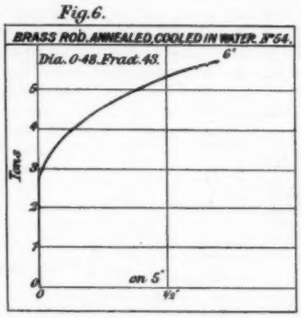


Fig. 7.

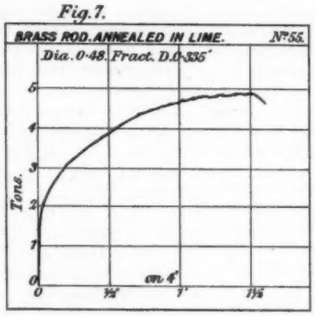


Fig. 8.

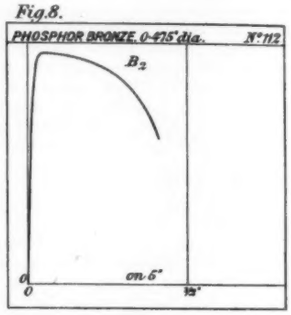


Fig. 9.

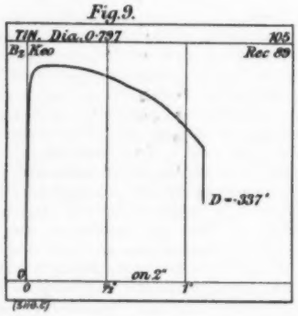
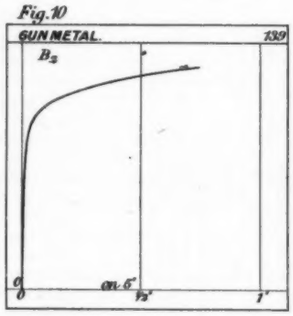


Fig. 10



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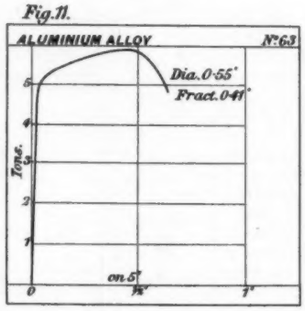

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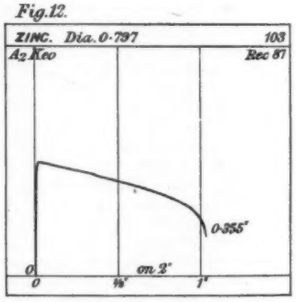
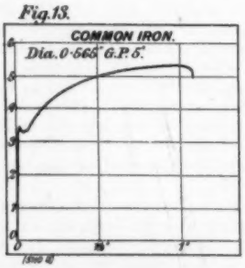


Fig. 13.



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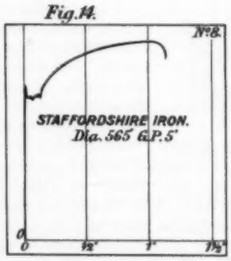

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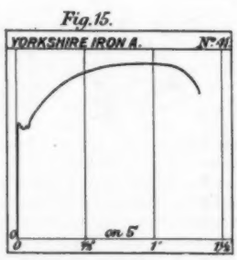


Fig. 16.

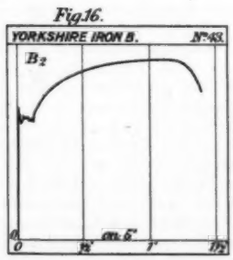
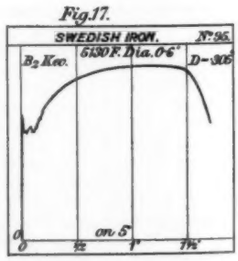


Fig. 17.



measured over lengths equal to the distances between the shoulders of the specimens to which Fig. 25 referred. Plotting the two sets of results in Fig. 26, the upper line gave the extension when the shoulders of the specimen were too far away from the gauged length to affect the extension of the latter, whilst in the case of the lower line the elongation had been reduced by the effect of the shoulders. Each graph, it would be seen, was compounded of two lines meeting in a point, and each component in the one graph was parallel to the corresponding component in the other graph.

The data obtained from this research on short and shouldered specimens enabled a test to be applied to the validity of the law of similarity for short specimens in which the effect of the ends was included with the effect of local contraction. Although the investigation was still incomplete, it had, the lecturer said, been found that notwithstanding the increasing extension between the shoulders as the length was increased, yet the percentage extension reckoned on geometrically similar specimens was substantially the same. Assuming that an extended series of experiments generalised this result for short specimens, it would appear that a good figure of ductility could be obtained from short shouldered specimens provided that a standard was agreed upon. For example, if it were agreed that for tests for ductility —and, for the matter of that, other properties also—shouldered specimens should be used having a distance between the shoulders four times the diameter, comparative figures could be obtained, and the figures representing the ductility would be the same for the same material.

In Fig. 27, Professor Dalby proceeded, he had plotted the tenacity, contraction of area and elongation against the distance between the shoulders of the specimens, the material being a 30-ton steel. In Fig. 28 load-extension diagrams were given for specimens notched with a vee and with a round-nosed tool respectively.

In most of his experiments he had used a 100-ton Wicksteed machine, the maximum rate at which the load could be applied being such that some 2½ minutes elapsed before the fracture of the specimen. He had, however, with a new machine, been able to increase the speed of test very greatly. Thus, in the test represented by Fig. 29 the bar broke in 10 seconds, and in Fig. 30 in 4 seconds. The yield-point was quite as marked as in slow-speed tests, but higher as compared with the maximum load carried, and the total extension was increased. It was a matter of some interest to determine the duration of each portion of the test, and this, following a suggestion of Professor Mather, he had done by using an intermittent current supply to the lamp which provided the ray of light, used in his apparatus as an optical lever. The kind of diagram then obtained was indicated in Fig. 31, where the distance between the centres of successive dots represented $\frac{1}{4}$ of a second. the total duration of the test being 2.15 seconds.

Fig. 18.

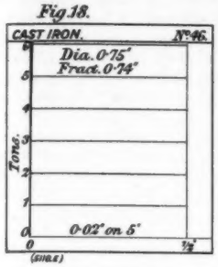


Fig. 19.

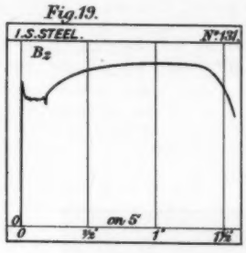
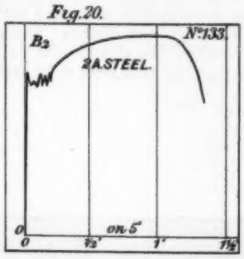


Fig. 20.



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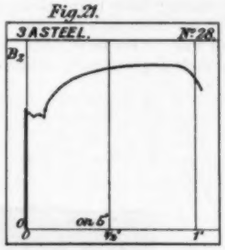

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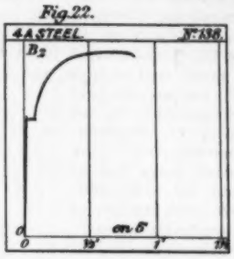
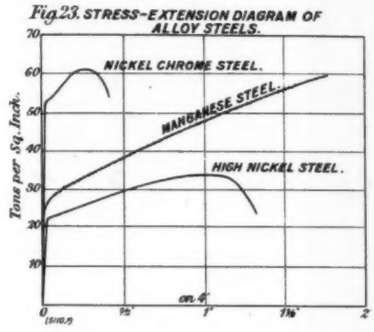


Fig. 23. STRESS-EXTENSION DIAGRAM OF ALLOY STEELS.



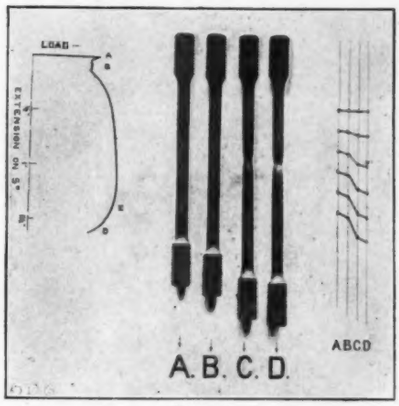


FIG. 24.

L.E. DIAGRAMS. SHORT SPECIMENS.

Fig. 25.

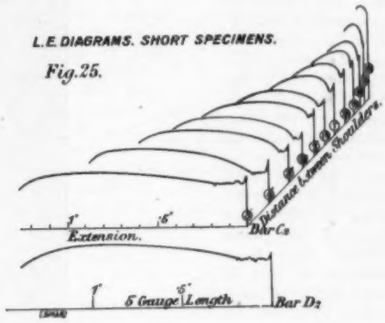


Fig. 26.

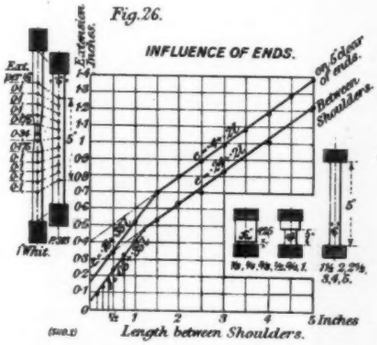


Fig. 27.

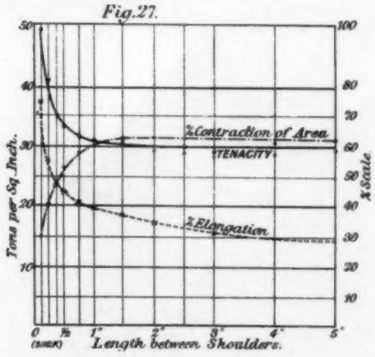


Fig. 28.

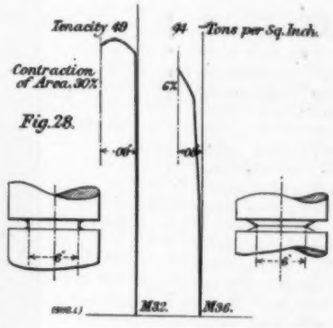


Fig. 29.

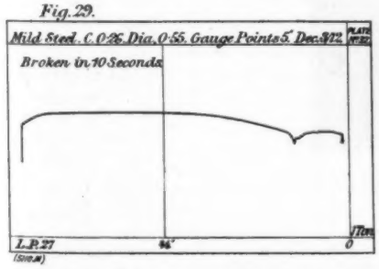


Fig. 30

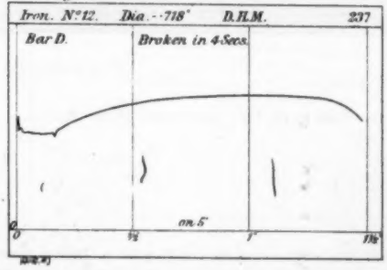
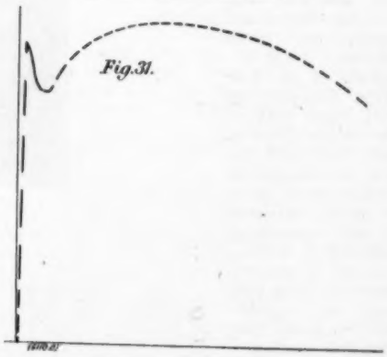
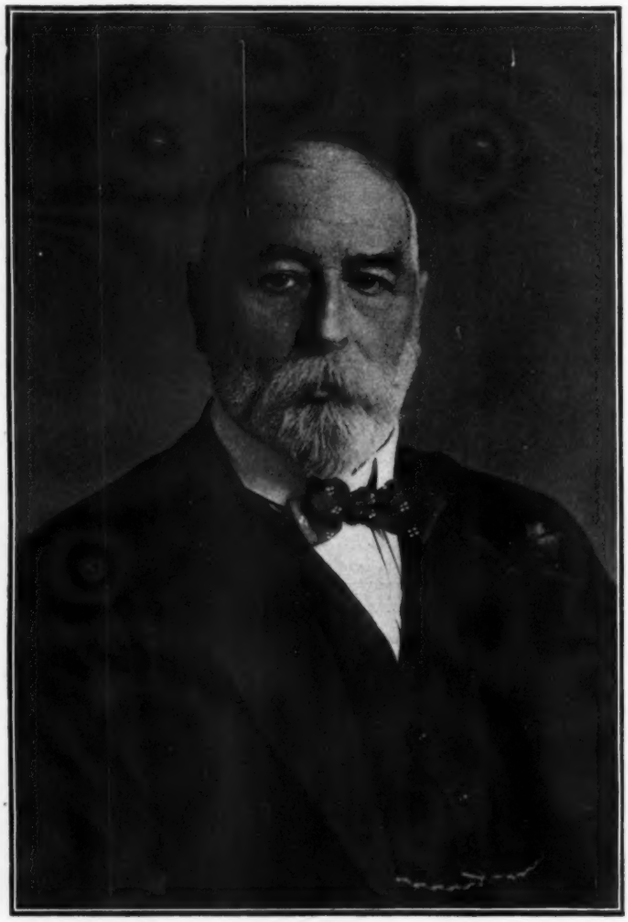


Fig. 31.



THE LATE MR. BENJAMIN HALL BLYTH.

WERE it the custom of engineers to celebrate the jubilee of their professional careers, Mr. Hall Blyth would have held his within a few days of his death last Sunday, for he commenced his pupilage with Messrs. B. and E. Blyth in Edinburgh in May, 1867. At that time he was just completing his eighteenth year, having been born in Edinburgh on May 25, 1849. He was the son of Mr. Benjamin Hall Blyth, who was, in his time, a noted civil engineer, and who took a great part in the construction of railways in all parts of Scotland. Unfortunately the father threw himself into his work with too much ardour and brought on an early death at the age of 48, just at the time when the subject of our memoir was starting on his career. The aptitude for engineering which the father had displayed descended to the son, and he soon made his mark as the representative of his firm in many of the great works which were entrusted to them. Nature had been generous to him in giving him a tall and massive frame and an impressive personality, which are very valuable endowments to a young man seeking for opportunities for the employment of his talents. The business of his firm provided him with ample opportunities of gaining experience, and as early as May, 1871, he became a member of the firm of Messrs. Blyth and Cunningham. Later the firm was Blyth and Westland, and afterwards Blyth and Blyth, the junior member being a nephew of Mr. Hall Blyth. So rapidly did work come that in the interval between 1871 and 1877 the firm was engaged on Parliamentary plans for works estimated to cost upwards of 6,000,000*l.* sterling, and had in progress works involving, with land, an expenditure of more than 2,500,000*l.* sterling.



[*From a photograph by Elliott and Fry.*

THE LATE MR. BENJAMIN HALL BLYTH.

Mr. Hall Blyth was elected a member of the Institution of Civil Engineers in 1877 and a member of council in 1900. In 1914 he became president, and his address was a short history of engineering in Scotland during the previous 50 years. He did not particularise the work with which he had been personally connected, but if he had it would have been seen that his activity had been spread over a wide area of the country. He was consulting engineer to the Caledonian, the North British and the Great North of Scotland railways, and these lines spread over the length and breadth of the land. He was also responsible for two great stations, the monumental Waverley station in Edinburgh and the Central station in Glasgow, besides being associated with the very important station at Carlisle. The Waverley station is known to thousands of tourists from all parts of the world, and is said to cover a greater acreage than any London terminus. The opening of the Forth Bridge in 1890 enormously increased the volume of traffic passing through the station, with the result that it became quite incapable of dealing with it, and in 1891 the North British Railway Company got an Act for rebuilding the station and duplicating the tunnels leading to and from it in both directions, including also a line to Leith, with a station there. Its reconstruction was surrounded with difficulty, partly on account of the site, but more so from the necessity of not disfiguring the neighbourhood, which is not only beautiful, but is also full of historic associations. The new Waverley station was begun in 1895 and opened for traffic in 1900. It is universally conceded that Mr. Blyth was very successful in designing an efficient and convenient structure, without obtruding it unduly on the scene.

Near to the Waverley station is the North Bridge, which spans the valley once occupied by the Nor' Loch, and forms the main connecting link between Old and New Edinburgh. This structure, too, is one that demanded more than engineering knowledge if it were to be in harmony with its surroundings, which include not only the valley gardens, but the Castle and the Calton Hill. The Caledonian Railway viaduct over the River Clyde at Glasgow was work of quite different character, but presented difficulties of its own, while the Glasgow Bridge was a municipal erection which had its features dictated by the city council. The old Glasgow Bridge was designed by Telford and built by Gibb in 1833. It was founded on wooden piles, and these became exposed by the dredging of the river and began to decay. It was rebuilt with properly secured foundations in 1899, the width being increased from 56 ft. to 80 ft. between parapets. These bridges were only a part of Mr. Blyth's work in this field, for he designed those over the Dee at Aberdeen, the Tay, at Perth, and many others.

In dockwork, Mr. Blyth was engaged at Grangemouth and at Methil. The Grangemouth Docks were acquired by the Caledonian Railway in 1867, and were enlarged by them in 1876. In 1906 Mr. Blyth undertook the construction of a dock about 30 acres in extent, with a depth of 30 ft. This dock connects directly, by means of a lock, with the Firth of Forth, and so does away with the necessity of using the River Carron as an entrance. The first Methil dock was opened in 1887, the second ten years later, and the third in 1913. The latter was constructed on the shore between high and low water, on a site exposed to very severe storms direct from the North Sea. Connected with it was a great sea wall running along low-water mark from Methil pier to the mouth of the River Leven, a distance of more than a mile. This wall varied from 20 ft. to 40 ft. wide at the base, and was 17ft. wide at the quay level. After completion it was protected by 50-ton blocks laid pell-mell to break the force of the sea. The basin was constructed between this wall and the shore. The Grangemouth Docks and the docks at Methil are fully equipped with the latest appliances for the shipment of coal, and they are both capable of dealing with large quantities, Methil alone having sufficient appliances to ship 7,000,000 to 10,000,000 tons per annum. The works were described in our issue of September 4, 1908.

It is, however, quite impossible to refer to more than a few salient points in the work of the subject of our memoir. He was called upon to advise the leading corporations in Scotland, as well as large

landowners, on matters affecting their interests. He was, further, in active demand as an expert witness, both in Scotland and at Westminster, his testimony always carrying great weight.

Engineering by no means engrossed the whole of Mr. Blyth's attention. He was an active politician, and contested East Lothian three times in 1900 and 1911; Unionist opinions, however, did not prove acceptable to the majority of the electorate. In recognition of his services he was in January, 1912, presented with his portrait, the presentation being made in the Corn Exchange, Haddington, by Mr. A. J. Balfour, M.P. Mr. Blyth was a member of the Territorial Force Association in Edinburgh. He was well known as an amateur golfer, and in his youth played Rugby football for Merchiston Castle Club. He was Lieutenant-Colonel in the Engineers and Railway Staff Corps and a member of the Royal Company of Archers, King's Bodyguard of Scotland. He was chairman of the Tramway Company of Edinburgh, and in this and other business matters displayed great ability. At the date of his death Mr. Hall Blyth held the following appointments:—Chairman of the Edinburgh and District Tramways Company, chairman of the Scottish Canadian Mortgage Company (Limited), director of the National Bank of Scotland, director of the Edinburgh Life Insurance Company, director of Merchiston Castle Schools (Limited), and director of the Royal Hospital for Sick Children. In 1872 he married Millicent, daughter of Thomas Edward Taylor, of Dodworth Hall, Yorkshire, who predeceased him in 1914, and he is survived by an only daughter, the wife of Mr. John Charles Couper, W.S.

THE COAL DEPOSITS OF SILESIA AND SAXONY.

In our issue of March 9 we gave an account of the deposits of coal in the western side of Germany, from which it appeared that there are great stores, likely to last many centuries at the present rate of consumption. A good deal of the coal, however, is at depths far below the possibility of working with existing methods, but it is, of course, not safe to assume that other methods may not be discovered in years to come. We now deal with coal deposits further east in Upper Silesia, Lower Silesia, and the Kingdom of Saxony, which are not all so important, but still are of considerable extent.

The Upper Silesian Coal District.—The coal formation of Upper Silesia, located between the river areas of the Oder and the Weichsel, comprises an area of 2,800 sq. km. (1,120 sq. miles), extending both into Austria and Russia. In Austria this formation comprises an area of 1,435 sq. km. and in Russia 194 sq. km. As regards the capacity of the coal-carrying strata, as well as the number and capacity of workable seams, no coalfields in the world surpass those of the Upper Silesian coal basin. There are in the western portion 124 seams, with an aggregate depth of coal of 172 m. (560 ft.), and in the east 30 seams, with an aggregate thickness of 62 m. (203 ft.). Also the saddle seams are remarkable for their depth, which, within their principal area, amounts to six workable seams, with an aggregate coal depth of 27 m. (89 ft.). The quantity of workable coal within the Prussian portion of these coalfields will appear from the subjoined table:—

The Upper Silesian Coal Deposits.

	To a depth of 1,000 m. Tons.	2,000 m. Tons.
Coking coal ...	8,000,000,000	18,200,000,000
Non-coking coal	78,245,000,000	147,787,000,000
Total ...	86,245,000,000	165,987,000,000

With the present coal production of Upper Silesia of 44,000,000 tons per annum, it would take 2,000 years to exhaust these coal deposits down to a depth of 1,000 m.

The Upper Silesian coal only to a small extent shows any capability of coking, and most of it is non-coking flame coal. Only in the western portions of the basin some of the deeper saddle seams produce coking coal. At Ostran-Karwinen there are numerous seams containing good fat coal; the capacity for coking as a rule decreases more and more towards the hanging wall of the formation; and towards the west; the coal percentage also decreases towards the west.

The cause for this variable capacity for coking is attributed to the circumstance that the seams have been formed from material coming from the west. Hence the western coal layers were earlier covered with gravel and clay than the eastern, and were therefore exposed to the influence of the atmosphere for a relatively shorter time. The yield of the Upper Silesian coking coal of coke and by-products will appear from the subjoined table:—

	(1) Per cent.	(2) Per cent.	(3) Per cent.	(4) Per cent.	(5) Per cent.	(6) Per cent.	(7) Per cent.	(8) Per cent.	(9) Per cent.	(10) Per cent.	(11) Per cent.	(12) Per cent.	(13) Per cent.
Coke	74.8	73.5	73.44	73.4	72.6	72.2	71.5	71.0	70.0	67.90	67.55	66.00	65.33
Ash in coke	10.0	7.5	11.09	11.0	11.0	10.3	11.0	10.5	7.5	12.0	11.0	13.0	9.5
Tar	3.7	3.9	3.67	4.98	4.9	3.35	3.70	3.70	3.2	3.71	3.35	3.5	3.28
Sulphate of ammonia	1.4	1.23	1.26	1.3	1.3	1.17	1.19	1.20	1.3	1.22	1.16	1.2	1.16
Benzol	1.1	1.15	0.82	0.97	1.08	1.02	1.05	1.20	1.15	1.10	1.12	1.1	1.03

The Nether Silesian Coal Basin. — The coal deposits of Nether Silesia extend from the slopes of the Riesengebirge at Landeshut and Schatzlar beyond the German frontier into Bohemia. Only the Waldenburg and the Neuroder districts are of importance. The coal deposits within these coalfields in Prussia, to a depth of 1,000 m., are estimated to contain 1,233,000,000 tons, and to a depth of 2,000 m. an additional quantity in the two districts just mentioned of 1,711,000,000 tons—a total, consequently, of 2,944,000,000 tons; which total may be swelled by further exploratory work. The annual coal production of Nether Silesia amounts to 5,300,000 tons, and if this production were maintained the deposits down to 1,000 m. would last 200 years, and those down to 2,000 m. more than 500 years.

In the Nether Silesian coal deposits one cannot very well speak about a fat or a flame coal group, as elsewhere in Germany, inasmuch as the character of the coal often varies within the same seam. All the Nether Silesian coal is crushed before coking, whether it be necessary or not, for the purpose of producing a compact coke. In the Waldenburg district the coking coal constitutes 50 to 60, often 70 to 80, per cent. of the production; in the Neuroder district, on the other hand, only few seams are found with coking coal, which, however, on account of the good local demand, is not coked. The appended table contains the particulars of the distillation products of the Nether Silesian coal:—

	(1) Per cent.	(2) Per cent.	(3) Per cent.	(4) Per cent.	(5) Per cent.	(6) Per cent.
Coke	83.0	81.0	81.0	80.5	78.0	75.00
Ash in coke	9.0	8.0	10.0	6.8	9.75	9.50
Tar	3.3	2.5	2.5	3.6	3.5	3.65
Sulphate of ammonia	0.87	1.0	0.8	1.0	1.05	0.97
Benzol	0·9	1.25	0.4	0·8	0·67	0.65

Minor Prussian Coal Districts.—North of Ibbenbüren, at Schaffberg, not far from Osnabrück, lies a smaller coal district, some 13 km. long, and at its broadest 5 km. broad. The coal in the same seam consists both of more and of less coking coal, with from 84.5 to 90.4 per cent. C. In the continuation of the longitudinal axis of this deposit in a south-eastern direction the Hüggel coal formation is located, 7 km. to the south-east of Osnabrück; the coal from this place contains from 14.7 to 22.8 per cent. of gas, and thus resembles the smiths' coal and half-fat coal of the Ruhr district. The coal formation again appears, at Piesberg, to the north east of Hüggel, the dimensions there being limited to 2 km. long and 1.5 km. broad. The coal, owing to the slight depth of the covering strata and the violent disturbances they have undergone, is exceedingly lean (96.14 to 97.77 per cent. C), and has an anthracitic character. Of more importance than the above-mentioned are the Wealden coalfields in north-western Germany, at Deister, and at Obernkirchen (Schaumburg). The main bed in the Schaumburg basin contains excellent coking coal when covered with Wealden clay, but lean coal when the covering strata are sandstone. The capacity of these coalfields amounts to 247,000,000 tons, which, with the present production of 900,000 tons, should last for 250 years.

The Kingdom of Saxony.—The production of coal in Saxony takes place in three districts, in those of Zwickau, Lugau-Oelsnitz and Döhlen. The Zwickau basin lies between Chemnitz and Zwickau, and covers an area of some 20 sq. km. Predominant amongst the varieties of coal is a bright sort with about 36 per cent. of volatile substances. Contrary to what is the case with some coal containing about 26 per cent. of gas, this coal will coke. The following table contains particulars as regards the distillation products of the Zwickau coal:—

	Per cent.
Coke	75.00
Ash in coke	9.00
Tar	4.00
Sulphate of ammonia	1.30
Benzol	1.00

The Lugau-Oelsnitz district comprises the towns of Lugau, Oelsnitz, Gersdorf and Hohndorf. The coal is principally the second kind referred to above. The non-coking coal of these coalfields contains smaller quantities of volatile substances than the same class of coal in the Zwickau district.

The Döhlen coal deposits are situated south-west of Dresden and cover an area 20 km. long and 6 km. broad. The coal generally contains 31 per cent. of gas and lends itself well to coking.

The coal deposits of the kingdom of Saxony have a capacity of 225,000,000 tons, which, with the present production of about 5,500,000 tons per annum, will be exhausted in about 40 years.

Taking the aggregate capacity of the German coal deposits, one arrives at a total of close upon 410,000,000,000 tons, of which Westphalia and Upper Silesia respectively account for 50 and 40 per cent. The subjoined table contains some figures with further details in this connection.

In connection with this table it should be noted that the North Crefeld district deep-level quantity only refers to a depth of 1,200 m. and not 2,000 m., and for the Brüggen-Erkeleng district the deep-level limit is only 700 m.

THE COAL DEPOSITS OF GERMANY.

Coal District.	To a Depth of 2,000 m. Tons.	Per cent.	To a Depth of 1,000 m. Tons.	Per cent.	Life of Deposits with Present Production.
Ruhr	213,566,000,000	52.90	45,029,000,000	29.76	
North Crefeld	7,100,000,000	1.73	7,100,000,000	4.69	2,000 years.
Brüggen-Erkeleng	1,746,000,000	0.43	1,746,000,000	1.15	
Aachen	1,612,000,000	0.39	1,612,000,000	1.07	500 ,,
Saar-Lorraine	16,548,000,000	4.04	7,898,000,000	5.22	1,000 ,,
Upper Silesia	165,987,000,000	40.48	86,245,000,000	57.00	4,000 ,,
Nether Silesia	2,944,000,000	0.72	1,232,000,000	0.81	500 ,,
Obernkirchen	247,000,000	0.06	247,000,000	0.30	252 ,,
Saxony	225,000,000	0.06	225,000,000	0.30	40 ,,
Totals	409,975,000,000		151,334,000,000		

Of the grand total of 409,975,000,000 tons given in the above Table as available for deep-level production, only 290,163,000,000 tons are assumed to be worth working. In the case of the first five of the above-named districts, considerable—both probable and possible—increases may be reckoned upon, and the same remark, more or less, applies to most of the other districts.

NOTES.

CORROSION AND THE STRENGTH OF BRASS.

VARIOUS recent investigations indicate that brass, and possibly other alloys and iron, will lose its ductility and crack when exposed while under tensile stress to corroding agents like ammonia. Whilst, however, E. Heyn and O. Bauer, from their experiments on internal stresses in cold-worked bars and in bearing metals, and others conclude that any tensile stress is injurious, E. Jonson, in his papers of 1915 (American Institute of Metals and American Society for Testing Materials) on "Failures of Forgeable Brass Bars and the Fatigue of Copper Alloys," maintained that the specimen would not fail unless the stress applied exceeded the elastic limit of the material. If the corrosive action were essentially chemical, one would expect that any large stress would be injurious to a certain extent, and that the simultaneous action of stress and of corrosion would not be indispensable; for any subsequent stress might enlarge any corrosive effect previously produced. In Technologic Paper No. 83 of the United States, Mr. Paul D. Merica supports the view that the action of corrosion and of tensile stress must be simultaneous to call forth failure of the brass, but that the tensile stress need not exceed the elastic limit, though the effect becomes much stronger then; he does not emphasise this latter point, however. He explains the phenomena on electrolytic grounds, and he experimented with two brass wires as electrodes, mounted vertically side by side in a glass tube containing an electrolyte; the one wire was under tensile stress, the other not, and he determined the potential difference between the two wires as tension was put on or released. The glass tube was closed at the bottom by a stopper of paraffin through which the wires passed; on the top of the electrolyte was a layer of oil to keep the air out. The brass of the wires contained 67.5 per cent of copper and 32.5 per cent. of zinc, and, further, traces of tin, lead and iron; the electrolyte was a decinormal solution of the sulphates of copper and zinc, or of zinc sulphate only. The wires were $\frac{1}{4}$ in. diameter and had been annealed. The stressed wire became electropositive to the other wire by 0.1 millivolt at a stress of 10,000 lb. per square inch, and by 1 millivolt at 30,000 lb. The load was put on in steps of 10,000 lb. per square inch. This stress, it is said, caused a lowering of the temperature, which masked the change in the electromotive force to a certain extent. The curves hardly look so simple as one might expect. The electrolytic argument is broadly the following. When the surface of a metal or alloy is roughened by corrosion, furrows or notches are formed, and when the specimen is stressed, the stress is much greater at the bottom of a furrow than at its upper edges; Leon found that the stress at the different parts of a crack might vary in the ratio 1 : 5. Now a stressed metal is electropositive to the metal not under stress; thus the bottom of a furrow would be much more corroded electrolytically than the surface, and the crack would tend to deepen under stress. We do not understand why the cracks should also become narrower as they grow inward; one might think that the crack would widen out at the bottom. According to Heyn the behaviour of a notch in a bar under tensile stress distinguishes ductile and brittle metals. In the former case the notch tends to smooth out; in the brittle metal the notch becomes sharper and finally causes fracture. Brass under combined stress and corrosion is said by Merica and others to fail with little elongation, thus not showing its usual ductility. We do not question the electrolytic effects under stress, but we should like to have it clearly established whether chemical corrosion by ammonia, followed by tensile stress, is not similarly injurious.

VISCOSITY OF BLAST-FURNACE SLAG.

Though the viscosity of blast-furnace slag must have a bearing on the metallurgical processes, it has hardly been investigated. There have been some fusibility determinations, but the difficulties of conducting viscosity measurements at temperatures at which iron is liquid seem to have been faced last year for the first time by the Bureau of Mines in their Pittsburg laboratory. The research (Technical paper 157) was undertaken by Messrs. Alexander L. Feild and F. H. Willcox by the method which M. Margules described in the Vienna Academy of Natural Science in 1881. In this method the liquid is confined between two concentric cylinders; the outer cylinder is rotated, and the torque is measured, which is exerted on the inner suspended cylinder, according to the formula: torque $= 4\pi\eta a^2 b^2 \omega/(b^2-a^2)$, where η is the viscosity to be measured, b is the diameter of the outer, and a that of the inner cylinder, L the common length of the two cylinders, and ω the angular velocity. As it is practically impossible to give the two cylinders the same length, an end effect will arise; this was corrected for by experimenting with inner cylinders of different lengths, but of the same diameter. A further question arises as to a possible slip at the boundary plane between the solid and the liquid in motion. In the experiments of Feild and Willcox the rotation was so slow—one rotation per second—that any slip could be disregarded. The arrangement was the following. The slag was fused in a graphite crucible, cylindrical, nearly 1 in. diameter and $1\frac{1}{2}$ in. high, placed in the cylindrical chamber, 6 by 3 in., of an electric resistance furnace; granular carbon confined between two concentric alundum tubes served as resister. The crucible was the outer cylinder of the test; its supporting rod was carried through the furnace bottom and turned through pulleys by an electric motor. The inner cylinder was a spindle of graphite, $\frac{1}{2}$ in. in diameter, 1 in. high, provided with a shaft nearly 5 in. long, screwed into a connecting rod, also of graphite, fitted above with a steel collar; into this collar was screwed the suspension rod, attached above to a steel ribbon, 0.15 mm. thick, 1.65 mm. wide, 4.2 cm. long. This ribbon and the mirror immediately below it were 21 in. above the slag level in the crucible, and remained cool, therefore; the suspension rod projected from the furnace, whose outer dimensions were 14 in. diameter and 18 in. height. In an experiment the crucible was filled with about 200 grammes of cold, powdered slag; fused, the slag would afterwards fill about half the crucible. When the slag melted the suspension system was lowered so that it rested for a moment on the bottom of the crucible; it was then raised again so that the spindle bottom was hanging 5 mm. above the crucible bottom. The heat was slowly raised to 1500 or 1600 deg C., while the crucible was turned. Observations (Holborn-Kurlbaum pyrometer) were taken during cooling and heating periods, roughly between 1200 and 1600 deg., on eight slags, ranging in silica from 18 up to 43.5 per cent, in alumina up to 35.3, and in lime up to 47.6 per cent. The viscosity-temperature curves were approximately rectangular hyperbolæ, and the fluidity-temperature curves (fluidity = 1/viscosity) therefore nearly straight lines. Taking the viscosity of water at 20 deg. C. as unit, the average viscosity of the slags at 1500 deg. was found to be 250, that is to say, the slag was more viscous than olive oil, but less so than castor oil at room temperature. The viscosities observed at 1,500 deg., probably the temperature at which normal slag flows from the cinder notch, ranged from 230 to 480. If 300 be assumed as the maximum viscosity satisfactory for slag action in the furnace, that viscosity was reached by the different slags at temperatures lying between 1,470 and 1,585 deg. The slag richest in silica and that richest in lime gave the highest viscosities, up to 3,000 at 1,300 deg., as was expected; a high percentage of alumina raised the initial softening-point, but had little influence on the viscosity of the fused slag. If more perfect refractories had been available the experiments might have been carried to higher temperatures.

PROPERTIES OF FOUNDRY IRON.

While agreeing with Mr. J. E. Johnson, jun., that the study of foundry iron has been rather neglected, we do not wonder that he had some difficulty in persuading iron founders to try his heterodox suggestion of making iron mechanically stronger by introducing oxygen into it. The four November and December issues of *Metallurgical and Chemical Engineering* of last year contain full accounts of the views which Mr. Johnson had previously communicated to the American Institute of Mining Engineers. Discussing in these articles first carbon and graphite, with special regard to the iron-carbon diagrams of Guertler-Wittorff and of Upton, he points out that the graphite in castings may separate from the melt without prior formation of cementite (in which he differs from Howe and Sauveur), and that this ejection of carbon does not stop by any means when the iron has become solid, nor until the iron is down to the lower limit of the red heat at least, and probably lower. The elements always present in iron, as well as any elements specially added and the effects of time, of course modify all the properties of iron in very complex ways. The investigation of the influence of oxygen had been suggested to Mr. Johnson by an inquiry into the differences in quality of charcoal iron and coke iron, and had been entered upon with a profound conviction that, next to sulphur, oxygen was the worst enemy of cast-iron; but he had found that iron, unusually strong originally, which remained strong after remelting in the crucible, owed its strength to its oxygen content. The oxygen content in his samples does not appear to have exceeded 0.7 per cent., which is comparable with the 0.30 per cent. to be found in charcoal iron. Together with Mr. L. Selmi, he conducted the very difficult analyses by burning the iron with oxygen in silica tubes heated by resistance coils; how he could by these means determine, for example, 0.009 per cent. of oxygen is not explained. The action of the oxygen is said to be fivefold. In the first instance the oxygen is found to throw the graphite into a nodular condition. Thus a high-temperature electric-furnace iron, free of oxygen, showed long streaks of graphite; an oxygenated iron, he argues, would solidify at a higher temperature than other iron, but the graphitisation would set in at lower temperature in an already solid matrix, and the graphite would be in the nodular condition. The oxygen is further supposed to change the forms of the crystallisation of high-carbon iron, to prevent the breakdown of the cementite needles into graphite and ferrite, and to affect the matrix and, lastly, the chilling power. To introduce oxygen into the iron, Johnson blows at low temperature in the converter; his oxygenated iron is thus low-temperature iron, as he himself points out. Finally he outlines the compositions desirable for the four main varieties of foundry iron. Silicon and the time element favour graphitisation on the whole, he thinks, and sulphur is always bad. Iron for machine and general castings should contain $1\frac{1}{4}$ or $1\frac{1}{2}$ per cent. of silicon (small-size castings more), up to 0.75 per cent. of phosphorus, from 0.6 to 1 per cent. of manganese, and a high oxygen percentage, especially if the castings are wanted dense; the carbon percentage would not be important, except when high strength was desired. In chilled castings (car wheels) the silicon should be low, the sulphur likewise, though some iron founders recommend, he says, a certain sulphur percentage for securing strength; a high carbon is desirable, but not above 4 per cent., and the oxygen percentage should also be high, as it influences the chilling power very strongly. For malleable iron the silicon should not exceed 1.75 per cent. at most, the phosphorus similarly not 0.25 per cent.; the carbon percentage might be as in chilled castings, though the limits are lower; the influence of oxygen is not sufficiently studied yet. Lastly heat-resisting castings (ingot moulds) require as high a carbon percentage as possible, the graphite to be present in large flakes, and absence of oxygen, which, like phosphorus, shortens the life of the moulds; the silicon percentage may rise to 1.5.

THE LATE MR. HERMANN HUBER.—Mr. H. Huber, the Swiss railway and mining engineer, who died in Zürich last month, in his seventy-third year, had seen service in foreign countries. When he attended the Zürich Polytechnic in 1862 to 1865 he had many later-famous men among his fellow-students—Clausius, Zeuner, Pestalozzi, Semper, and others. Leaving college, Huber became engineer on the Swiss North-Eastern Railway, and in 1869 joined the staff of the Turkish railway from Salonika to Constantinople at Deadeagatch. There he remained till 1875, when he returned to Switzerland and then emigrated to America, where he was mining engineer in Leadville (Colorado), in Socorro (Mexico) and, finally, general manager of the Kansas City Smelting and Refining Company in Argentine (Kansas). Returning to Europe in 1899, he retired.

ETCHING STEEL SECTIONS AT HIGH TEMPERATURES *IN VACUO*.

The Determination of the Line SE in the Iron-Carbon Diagram by Etching Sections at High Temperatures in Vacuo.*

By Professor N. TSCHISCHEWSKY and N. SCHULGIN (Tomsk, Russia).

It has been shown, in a paper recently read before the Russian Metallurgical Society,† that the preheating of sections prepared from iron-carbon alloys, in a gaseous atmosphere, prior to etching by gaseous reagents, does not give satisfactory results because of the decarburising action of such gases as nitrogen, and in particular of hydrogen. The surfaces of such preheated sections not having the same composition as they possessed before preheating will not, when etched, correspond with that point of the iron-carbon diagram corresponding to the carbon content of a given specimen. In order to remove all foreign influences it is necessary therefore to heat such sections *in vacuo*.

The best method of fixing the structure of a section at a high temperature would be to examine and photograph it directly at the required temperature. Unfortunately technical difficulties at present prevent this being done. In the investigation undertaken by the authors a sample of cement steel from the Urals containing 0.89 per cent. of carbon, 0.09 per cent. of silicon, 0.10 per cent. of manganese, 0.03 per cent. of phosphorus, and 0.02 per cent. of sulphur was taken, as well as a series of specimens of mild steel produced in a Tammann furnace in the author's laboratory, from soft Swedish nail iron containing 0.10 per cent. of carbon, 0.014 per cent. of silicon, 0.14 per cent. of manganese, 0.08 per cent. of phosphorus, and 0.0012 per cent. of sulphur, and a Swedish cast-iron containing 3.96 per cent. of carbon and a very small proportion of other impurities, such as 0.12 per cent. of silicon, 0.18 per cent. of manganese, 0.08 per cent. of sulphur, 0.02 per cent. of phosphorus, and 0.07 per cent. of copper.

Preparation of the Specimens.—The Tammann furnace, which was of an improved form, was capable of melting 220 grammes of alloy, the melting being carried out in an unglazed porcelain tube closed at one end. A charge consisting of small pieces of wrought iron and cast-iron was placed in the tube in alternating layers. When the furnace had been heated up beforehand, melting was effected in about 20 minutes. The charge was stirred several times and the tube returned to the furnace for another 20 to 30 minutes, after which the metal was poured into a mould. No visible oxidation occurred during fusion, as the furnace was covered with a bronze cylinder specially constructed and provided with a mica inspection hole, and a hole for the wire of the thermo-couple employed in obtaining the cooling curve of the alloy.

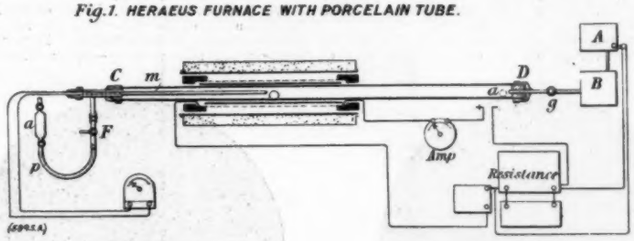
Three alloys were prepared, containing respectively 2.50 per cent., 1.505 per cent., and 1.25 per cent. of carbon. The cement steel and alloys were cut into discs and filed round, the ultimate area being about 0.5 square centimetre. The surface was rubbed smooth with emery paper and polished on a moistened cloth on which was spread alumina.

Arrangement of the Apparatus.—Chlorine was selected as the etching medium, because gaseous hydrochloric acid decarburises the steel by means of its dissociation products, *i.e.*, the hydrogen. The chlorine was prepared by the action of strong hydrochloric acid on crystals of potassium permanganate, and was washed through water, sulphuric acid, and calcium chloride. During the etching the chlorine combines with the iron, forming anhydrous chlorides which volatilise at a comparatively low temperature, the volatilisation products condensing, in the form of red scales, on the cooler portions of the furnace.

The samples were heated in a Heraeus furnace (Fig. 1) provided with a glazed porcelain tube. One end of the tube projected about 50 centimetres from the furnace and was provided with a stopper having a hole through which a glass tube passed. This tube was provided with a tap *g* connecting the furnace with a mercury pump B. The other end C of the tube was also provided with a perforated rubber stopper, through which passed a thin glazed porcelain tube *m*, 5 millimetres in diameter. This tube reached about the middle of the furnace and contained the thermo-junction of a Le Chatelier pyrometer. The end of the thermo-junction was connected with a Siemens-Halske millivoltmeter graduated for each 10 deg. C. One end of the glass tube was connected with a tap F communicating either with the atmosphere or with a vessel filled with chlorine. A rubber tube between the tap and the vessel with a stopper *p* served to regulate the flow of chlorine required for etching. The pyrometer was standardised against gold and barium chloride.

The Mode of Operation.—At the cold end D of the porcelain tube was placed a polished section *a* of the sample. The tube was then closed with a rubber stopper and luted with Mendelejeff's mastic. By turning the tap the furnace was connected with the mercury pump, and in 15 minutes a vacuum of several thousandths of a millimetre of mercury was obtained. For checking the degree of vacuum a mercury manometer *m* was employed, and when a high vacuum was needed a Crookes tube was used, the required vacuum being obtained when the yellow cathodal rays began to appear. The employment of the Crookes tube was the more convenient method,

Fig. 1. HERAEUS FURNACE WITH PORCELAIN TUBE.



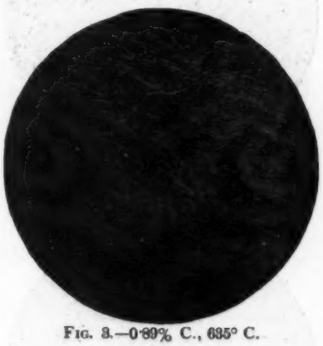


FIG. 3.—0·89% C., 635° C.

FIG. 4.—0·89% C., 695° C.

FIG. 5.—0.89% C., 715° C.

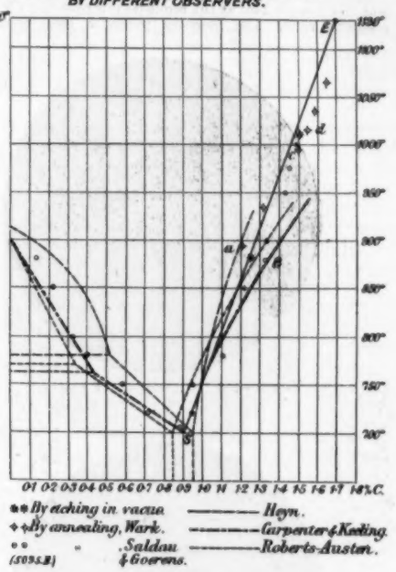
FIG. 6.—0·89% C., 750° C.

FIG. 7.—0·89% C., 780° C.

FIG. 8.—0·89% C., 905° C.

FIGS. 3 AND 4, MAGNIFIED 600 DIAMS.; FIG. 5, 360 DIAMS.; FIGS. 6, 7 AND 8, 370 DIAMS.; AND ALL REDUCED BY ONE-NINTH. ALL SECTIONS ETCHED IN CHLORINE *in vacuo* AT TEMPERATURES SHOWN.

Fig. 2. DETERMINATIONS OF CEMENTITE LINE BY DIFFERENT OBSERVERS.



* Paper taken as read before the Iron and Steel Institute on Friday May 4th, 1917.

† K. Krooglak, Journal of the Russian Metallurgical Society, 1915.

as it indicates continuously the maintenance of the vacuum without derangement of the apparatus, while with a McLeod vacuometer it is necessary at certain intervals systematically to test the vacuum. When a sufficient vacuum has been obtained the furnace is disconnected by means of the tap from the vacuum pump, the tap *g* being left open in order that the degree of vacuum may be ascertained. The furnace is heated and turned through an angle of 30 deg. to 40 deg. horizontally, whereupon the sample section rolls towards the central portion of the furnace until it reaches the porcelain tube containing the thermo-junction.

The furnace is then turned back to its original position and the sample kept at the requisite temperature for the requisite time. The mercury pump is then entirely disconnected by means of the tap *g*, in order to prevent the chlorine passing into it. A small amount of chlorine is allowed to flow into the furnace. After a few minutes the sample is rolled back to its previous position *a* by rotating the furnace, and cooled quickly at the end of the tube by means of cold water and snow. Air is then passed through, the stopper D opened, and the cold sample taken out for microscopical examinations.

A sample after etching by chlorine has a somewhat dull surface. With an excess of chlorine the surface becomes dark, due probably to the carbon. It having been noticed that samples in the open air were oxidised after a few minutes' exposure, the etched surface after removal from the furnace was covered by a thin layer of varnish, to protect it.

' *Preliminary Experiments.*—In order to investigate the course of the etching by chlorine *in vacuo* the authors took two samples, one of cement steel containing 1.89 per cent. carbon, and the other an alloy produced in the Tammann furnace and containing 2.5 per cent. carbon. The results of the etching of the cement steel were, as follow :—At a temperature below that at which the iron assumes the allotropic state γ, the etching shows a very distinct pearlitic structure, although a little coarser than is observed on etching with ordinary cold reagents. Fig. 3, page 485, shows a section etched by chlorine at 635 deg. C., and Fig. 4 one at 695 deg. C.

Fig. 5, page 485, shows a section etched at 715 deg. C. This photomicrograph shows the presence of fine crystals which have had insufficient time to assume their normal structure—that is, a region of hard solution. Some crystals have a very clean surface, whilst others have a granular structure. In Fig 6 the same specimen etched at 750 deg. shows a polyhedric structure.

Figs. 7 and 8, page 485, show the same steel etched by chlorine at temperatures of 780 deg. and 905 deg. C. respectively. The micrographs reveal polyhedrons having thin boundaries between the crystals.

The secondary structures martensite, troostite, osmondite and sorbite were not observed in these experiments.

The influence of the temperature on the size of crystals is obvious. Their size increased with higher temperatures (Figs. 6, 7, 8).

The polyhedric structure observed during the etching by chlorine *in vacuo* shows very thin lines at the boundaries between the crystals as compared with those observed on etching with previous heating. During the etching *in vacuo* by chlorine of a specimen containing 0.89 per cent. carbon a pearlitic structure was found up to 695 deg., the polyhedric appearing at 715 deg. It may therefore be assumed that the pearlite line lies between 695 deg. and 715 deg. C. A cooling curve obtained by the ordinary method shows an arrest at 702 deg. C.

The other specimen, containing more carbon (namely 2.4 per cent.) and etched by chlorine with gradual increase of temperature, shows a decrease in the amount of cementite which was dissolved at the higher temperature.

Fig. 9, below, shows an alloy with 2.5 per cent. carbon etched by chlorine at 650 deg. The photograph shows a network of cementite and also cementite in thin plates. The dark spots represent oxide, and appeared when the specimen was exposed to air.

Fig. 10, below, is the same alloy etched by chlorine at 925 deg. The photomicrograph shows a solution of the thin crystals of the cementite and a thinning of its network. Between the network of the cementite may be observed a polyhedric structure representing the hard solution of carbon in iron.

The Determination of the Points on the Line SE.—The determination of the cementite line has been made by several authors, Roberts-Austen,* Heyn,† Carpenter and Keeling‡, and more recently—by a method of annealing—

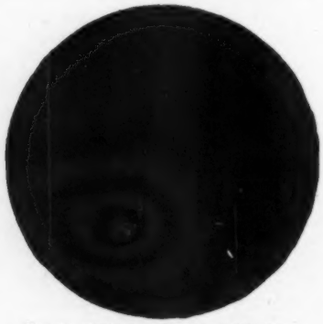


FIG. 9.—2·5% C., 650° C. Chlorine.

FIG. 10.—2·5% C., 925° C. Chlorine.

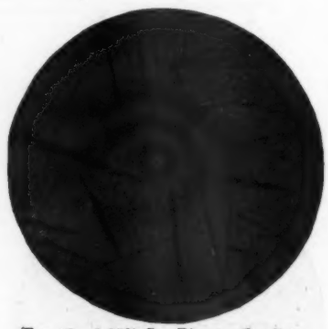


FIG. 11.—1·25% C. Picrate of sodium.

FIG. 12.—1·25% C., 875° C. Chlorine.

FIG. 13.—1·25% C., 890° C. Chlorine.

FIG. 14.—1·25% C. Picric acid.

FIG. 15.—1·25% C. Picrate of sodium.

FIG. 16.—1·25% C. Picrate of sodium.

FIG. 17.—1·505% C. Picrate of sodium.

FIGS. 9 TO 17. MAGNIFIED 370 DIAMETERS AND REDUCED BY ONE-NINTH.

by Wark§ and Saldau and Goerens.‖ The results of their work are shown in Fig. 2.

There is some doubt as to the accuracy of the method of tempering, as the structure which is fixed after tempering can hardly correspond with the exact temperature of tempering. It must be borne in mind that a specimen cools in the air before being placed in water, while the water itself assumes the spheroidal state around a

* Roberts-Austen, "Fifth Report of the Alloys Research Committee"; *Metallographie*, 1899, vol. ii, p. 186. ENGINEERING, Feb. 17 and 24, and March 3, 1899.

† Heyn, *Metallographische Untersuchungen von Eisenlegierungen Verhandl. d. Ver. zu Beford. d. Gewerbeff.*, 1904, p. 355.

‡ Carpenter and Keeling, Journal of the Iron and Steel Institute, 1904, No. I, p. 224. ENGINEERING, March 20, 1904.

§ H. J. Wark, *Metallurgie*, 1911, p. 104.

‖ Saldau and Goerens, Journal of the Russian Metallurgical Society, 1914, p. 789.

specimen, which further delays the conduction of heat. The result is that the point obtained by this method may be higher than it really should be.

The authors' experiments to determine the cementite line were based on the following considerations. During the heating of a sample above the pearlite line the cementite begins to dissolve and disappears entirely at the temperature corresponding with the points on the line SE. The specimens which do not show the presence of cementite after the required heating and etching by chlorine must therefore have been heated either very nearly to the line SE or somewhat above it.

Taking into consideration that specimens with a distinctly polyhedric structure nearly always suggest overheating above the line SE, it was decided to take an average between the two nearest temperatures, where one specimen shows a polyhedric structure and the other shows only traces of the cementite. To determine the points the authors took pieces of the alloy steel mentioned above, polished them and heated them *in vacuo* at gradually increasing temperatures. Before chlorine was passed the samples were left in the furnace for half an hour or more. The difference of temperature during heating was not more than 2 deg. to 3 deg., otherwise the experiment was repeated. A fresh specimen was always taken for etching, after which the sections were subjected to microscopical examinations. During an increase of the temperature there was noticed a distinct thinning of the crystals of the cementite, which afterwards disappeared. The intervals of the temperatures near the points were taken between 10 deg. and 15 deg. An alloy containing 1.25 per cent. carbon was first investigated. Fig. 11 represents this alloy, etched by picrate of sodium. The cementite here was crystallised mostly as needle-like crystals.

Fig. 12 shows the same alloy, which was heated in the furnace at 875 deg. and etched by chlorine. From this photomicrograph can be seen the needle-like crystals of cementite, which become thinner than in the previous case, and are enclosed in a polyhedric matrix of dissolved pearlite.

Fig. 13 shows the same alloy, containing 1.25 per cent. carbon, etched by chlorine at 890 deg. The photograph shows the polyhedric structure. In this instance all the cementite was transformed into hard solution.

Photographs 12 and 13 show therefore that the cementite line passes between 875 deg. and 890 deg. C. when the carbon percentage corresponds with 1.25 per cent. As a boundary of the presence of cementite in this interval the point corresponding with the average between these temperatures, namely 883 deg., has been assumed (see Fig. 2).

In regard to the determination of the other point of the line SE, the authors took a sample containing 1.505 per cent. carbon.

Fig. 17 shows its microstructure after etching by picrate of sodium. The greater part of the cementite here forms needle-like crystals, and only a small amount forms a net located near the boundaries of the crystals.

Fig. 18 shows the same alloy, etched by chlorine, at 1005 deg. Here it is seen that the needles of the cementite have not yet been dissolved, and only become thinner in comparison with those of the previous example.

Fig. 19 shows the same alloy etched by chlorine at 1015 deg. C. The photograph shows the formation of the polyhedric structure. All the cementite is transformed into hard solution.

From photomicrographs 18 and 19 it may be seen that the point of the line SE must be between 1005 deg. and 1015 deg., the average, 1010 deg. C., being taken as correct.

From the specimens shown at Figs. 12 and 13 and Figs. 18 and 19 were filed off layers about 1 millimetre in thickness. The surfaces were polished and etched by picric acid and picrate of sodium. It was discovered that the cementite of the samples shown in Figs. 12 and 18 forms a network of several needle-like crystals.

Samples 13 and 19, which are beyond the line SE, contain the cementite in the form of a network. Evidently all the needle-like crystals of the cementite were dissolved, and there were no traces of them as centres of crystallisation, but all the cementite occurred as a network near the boundaries of the crystals.

Figs. 14 and 20 are photographs of a filed specimen, shown in Figs. 12 and 18, and etched by picric acid. Here the cementite appears in the form of network of white needle-like crystals. Figs. 15 and 21 show the same specimens etched by picrate of sodium. The cementite here is coloured.

Figs. 16 and 22, which are, on the other hand, photographs of specimens heated above the line SE, show only a network of cementite near the boundary of the crystals. They correspond with photographs 13 and 19, prepared after etching by chlorine. The results of the investigation are shown in the annexed table.

Assuming as a maximum limit of the saturation of iron by the cementite the point corresponding with 1.7 per cent. carbon and 1130 deg. C., and as the eutectoid point 0.9 per cent. carbon and 700 deg. C., and connecting them by a straight line, it is found that the points corresponding with the end of dissolution and the beginning of the appearance of the cementite are near this line. The point corresponding with 1.25 per cent. carbon and 883 deg. C. is a little below the line, almost at the same distance from the points *a* of H. Wark and from the point *b* of Saldau and Goerens in the direction of a perpendicular to the line SE. The second point, corresponding with 1.505 per cent. carbon and 1010 deg. C., lies a little further from this, and is placed with regard to the nearest points *d* (Wark) and *c* (Saldau and Goerens) in a reverse relation, that is, it is at the same distance as the point of Saldau and Goerens, but nearer than Wark's point.

The proximity of these points to the straight line between the points S and E justifies the supposition that the line ES is a straight line.

FIG. 18.—1·505% C., 1005° C. Chlorine.

FIG. 19.—1·505% C., 1015° C. Chlorine

FIG. 20.—1·505% C. Picric acid.

FIG. 21.—1·505% C.

FIG. 22.—1·505% C.

Both etched by picrate of sodium.

FIG. 18, MAGNIFIED 80 DIAMETERS; FIGS. 19 TO 22, 370 DIAMETERS, AND ALL REDUCED ONE-NINTH.

No. of Sections.	Per Cent. Carbon.	Temperature.	Etching Medium.	Magnification.	Structure.	Remarks.
3	0.89	635	Chlorine ..	600	Striped pearlite ..	Cement steel.
4	0.89	695	,, ..	600	Pearlite	,, ,,
5	0.89	715	,, ..	360	Polyhedric	Fine crystals having no time to form.
8	0.89	750	,, ..	370	,, ...	Size of crystals increase.
7	0.89	780	,, ..	370	,, ...	,, ,, ,,
8	0.89	905	,, ..	370	,, ...	,, ,, ,,
9	2.5	650	,, ..	370	Cementite	Cast steel. The dark spots are oxides.
10	2.5	925	,, ..	370	Cementite and austenite	Thinning of cementite.
11	1.25	925	Picrate of sodium	370	Needle-like crystals of cementite	Cast specimen not annealed.
12	1.25	875	Chlorine ..	370	,, ,,	Needle-like crystals of cementite become thinner.
13	1.25	890	,, ..	370	Polyhedric	Complete solution of needle-like crystals of cementite.
14	1.25	890	Picric acid	370	Cementite	After filing off a layer from specimens 13 and 14.
15	1.25	890	Picrate of sodium	370	,, ...	,, ,, ,, ,,
16	1.25	890	,,	370	,, ...	,, ,, ,, ,,
17	1.505	890	,,	370	,, ...	Cast specimen not annealed.
18	1.505	1005	Chlorine ..	80	,, ...	Thinning of needle-like crystals of cementite.
19	1.505	1015	,, ..	370	Polyhedric	Complete solution of needle-like crystals of cementite.
20	1.505	1015	Picric acid	370	Cementite	After filing off a layer from specimens 19 and 20 of 1 mm.
21	1.505	1015	Picrate of sodium	370	,, ...	,, ,, ,, ,,
22	1.505	1015	,,	370	,, ...	,, ,, ,, ,,

THE BLACK LIST.—By an Order of Council dated April 27 last all names of residents in Porto Rico, the Philippine Islands and the United States of America are removed from the list of those with whom British subjects are forbidden to trade.

STEEL IN THE TRANSVAAL.—At Vereeniging the Union Steel Corporation of South Africa, Limited, have for some time past been smelting steel from local scrap, and are now turning out about 1,000 tons a month of excellent quality.

FOUNDATION PRESSURES.—The coal plant of the New York Steam Company at Water-street, New York, stands on a concrete slab-and-girder mat over wet sand. It is surrounded by a ring of interlocking sheet steel piling, and the pressure on the sand is 5,004 tons per square foot. A trial installation loaded to 6 tons settled 0.061 ft. in 237 hours. The details are given in *Engineering News* of March 22.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—The first meeting of this association to be held in Huddersfield took place in the Technical College on May 5, 1917, and representatives attended from Halifax, Brighouse, Sowerby Bridge, Elland and Huddersfield. Speakers from Manchester and Leeds addressed the meeting, and it was ultimately decided to elect a sub-committee which would further the objects of the association in the above district. Arrangements are being made to hold a meeting in Halifax.

A METHOD OF FINDING THE I.H.P. FOR STEAMSHIPS.*

By E. W. DE RUSETT.

THE object of this paper is to suggest a ready means of estimating the power required for the propulsion of steamers which the writer initiated some years ago and has since developed. It will be observed that the calculations circle round a standard block coefficient which is based on the speed and length of the vessel. The power of the proposed vessel is arrived at by direct reference to the trial trip records of vessels of a similar character. The inquiry embraces the following rules:—

1. For basis purposes select the trial trip records of two suitable vessels, A^2 and A^3, preferably of similar design to the proposed steamer A^1.

TABLE A.

—	A^1.	A^2.	A^3.
Length B.P.	ft. in. 452 0	ft. in. 481 0	ft. in. 391 0
Breadth, extreme	56 6	55 5	48 2
Trial draught	27 8	27 5½	20 8
Block coefficient	0.778	0.730	0.678
Coefficient of ⊠	0.98	0.974	0.965
Displacement, tons	15,540	15,190	7,500
Speed required	12 knots	—	—
Corresponding speed to A^1 by ratio of $\sqrt{L}$	—	12.38	11.16
Speed ratio on corresponding speeds $\frac{V}{\sqrt{L}}$	0.565	0.656	0.565
Standard block $1.060 - \frac{V}{\sqrt{L} \times 2}$ at corresponding speeds	0.778	0.778	0.778
Admiralty coefficient obtained on trial at corresponding speeds	—	308	304
Relative fineness of block to standard block	unaltered	6.2 per cent. finer	12.8 per cent. finer
Admiralty coefficient increased by 1 per cent. for each 3 per cent. of relative fineness (Table C)	—	2⅓ per cent. = 6	4.3 per cent. = 13
Admiralty coefficient adjusted for relative fineness	—	314	317
Admiralty coefficient for A^1 ship, being mean of A^2 and A^3	315.5		
Corresponding i.h.p. $\frac{D^{\frac{2}{3}} \times V^3}{C}$	3,400		
Margin on power for contingencies, 5 per cent.	170		
Total i.h.p.	3,570		

TABLE B.—*Table Showing Estimate of Power required for a Vessel with a Cruiser Stern.*

—	Proposed S.S.	Basis Vessels with Cruiser Sterns.	
	A^1.	A^2.	A^3.
Length, B.P.	ft. in. 530 0	ft. in. 580 0	ft. in. 306 0
Length on load-water line	550 0	600 0	317.6
Breadth, extreme	66 0	72 0	42 0
Trial draught, B.K.	27 0	28 5	15 0
Block coefficient	0.650	0.628	0.547
Coefficient of ⊠	0.96	0.95	0.926
Displacement, tons	18,080	21,920	3,118
Speed required on trial	17 knots	—	—
Corresponding speed to A^1 by ratio of $\sqrt{L}$	—	17.757	12.916
Speed ratio at corresponding speed $\frac{V}{\sqrt{L}}$	0.725	0.725	0.725
Standard block $1.060 - \frac{V}{\sqrt{L} \times 2}$ at corresponding speeds	0.697	0.697	0.697
Admiralty coefficient obtained on trial trip at corresponding speeds	—	345	309
Relative fineness of block coefficient to standard coefficient	* 6 per cent. finer	9 per cent. finer	21 per cent. finer
Admiralty coefficient increased by 1 per cent. for each 3 per cent. of relative fineness (Table C)	2 per cent.	3 per cent. = 10	7 per cent. = 21
Admiralty coefficient adjusted for relative fineness	—	355	330
Admiralty coefficient for A^1 ship, being mean of A^2 and A^3	343		
Add one-third of the relative fineness = 2 per cent. of the Admiralty coefficient	7*		
Admiralty coefficient	350		
Corresponding i.h.p. $\frac{D^{\frac{2}{3}} \times V^3}{C}$	9,670		
Margin on power for contingencies, 5 per cent.	480		
Total i.h.p.	10,150		

* In this instance the block of the proposed vessel A^1 is 6 per cent. finer than the standard block, as economy of power was of more importance than deadweight. Credit for this is given, as noted above, when adjusting the Admiralty coefficient.

* Paper read at the North-East Coast Institution of Engineers and Shipbuilders, April 27, 1917.

2. Find the speeds of A^2 and A^3 which correspond to the specified speed of A^1 by the ratio of $\sqrt{L}$.

3. Obtain the speed ratio at the corresponding speeds.

4. At the corresponding speeds measure the Admiralty coefficient from the coefficient curves of A^2 and A^3.

5. Find the standard block coefficient for vessels A^1, A^2 and A^3 by the following formula $C - \frac{V}{\sqrt{L} \times 2}$, where C is a constant 1.060, V and L being the speed and length respectively. Compare the block coefficient of these two vessels with the standard block.

6. When the relative fineness or fullness of the ordinary and standard blocks has been found, correct the Admiralty coefficients at the corresponding speed ratios.

7. Of course it is prudent to have a margin of power for contingencies, and on this account it is suggested that an addition be made of 5 per cent. if the basis ships have been tried on the Skelmorlie mile, or 3 per cent. if they have been tried on the Whitley mile—the conditions being normal.

We will now refer to Tables A and B, which show the method of applying the foregoing rules. Column A^1 contains the particulars of an ordinary commercial vessel, the power for which has to be ascertained. Columns A^2 and A^3 contain the particulars of vessels which have been tried on the measured mile.

With the object of arriving at the effect of fineness of a model on the Admiralty coefficient, the writer has prepared the following Table C, with the kind assistance of Mr. H. Bocler. It is built up from the valuable paper read by Mr. Baker at the Institution of Naval Architects in 1914:—*

TABLE C.—*Effect of the Admiralty Coefficients on Models of Varying Degrees of Fineness.*

Models.	Speed. Knots.	Speed Ratios $\frac{V}{\sqrt{L}}$	Block. —	Per cent. to Basis Model.	$\frac{D^{\frac{2}{3}} \times V^3}{I.H.P.}$	Admiralty Coefficient. In per cent. to Basis Coefficient.	I.H.P. at 50 per cent. Propelling Efficiency.
56*a*	8	0.40	0.677	8.8 per cent. finer	328	2.44 per cent. higher	695
30*b*	8	0.40	0.743	Basis ..	320	Basis ..	760
86*c*	8	0.40	0.812	9.3 per cent. fuller	279	12.8 per cent. lower	920
56*a*	9	0.45	0.677	8.8 per cent. finer	330	2.42 per cent. higher	980
30*b*	9	0.45	0.743	Basis ..	322	Basis ..	1,075
86*c*	9	0.45	0.812	9.3 per cent. fuller	276	14.2 per cent. lower	1,320
56*a*	10	0.50	0.677	8.8 per cent. finer	327	2.7 per cent. higher	1,360
30*b*	10	0.50	0.743	Basis ..	318	Basis ..	1,490
86*c*	10	0.50	0.812	9.3 per cent. fuller	264	15.4 per cent. lower	1,850
56*a*	11	0.55	0.677	8.8 per cent. finer	323	6.2 per cent. higher	1,835
30*b*	11	0.55	0.743	Basis ..	304	Basis ..	2,060
86*c*	11	0.55	0.812	9.3 per cent. fuller	265	12.8 per cent. lower	2,515
56*a*	12	0.60	0.677	8.8 per cent. finer	314	4.7 per cent. higher	2,450
30*b*	12	0.60	0.743	Basis ..	300	Basis ..	2,720
86*c*	12	0.60	0.812	9.3 per cent. fuller	251	16.3 per cent. lower	3,430
56*a*	13	0.65	0.677	8.8 per cent. finer	313	4.7½ per cent. higher	3,120
30*b*	13	0.65	0.743	Basis ..	299	Basis ..	3,470
56*a*	14	0.70	0.677	8.8 per cent. finer	313	11.8 per cent. higher	3,900
30*b*	14	0.70	0.743	Basis ..	280	Basis ..	4,600
56*a*	14.5	0.725	0.677	8.8 per cent. finer	312	22.4 per cent. higher	4,350
30*b*	14.5	0.725	0.743	Basis ..	255	Basis ..	5,640

It should be stated that the three models were for vessels each 400 ft. long by 52.25 ft. beam, and 23.25 draught, midship section coefficient 0.98. The displacements being for model 56*a*, 9,396 tons; model 30*b*, 10,310 tons; and 86*c*, 11,244 tons; the block coefficients being respectively 0.677, 0.743 and 0.812. The parallel middle bodies varied in length from 42 ft. to 260 ft. It will be noticed when the basis model 30*b* was fined to the extent of 8.8 per cent., the displacement reduced by 914 tons, and propelled at speeds 8, 9 and 10 knots (speed ratios 0.40 to 0.50), that the Admiralty coefficient was only raised on an average of 2.52 per cent., or one-third of the percentage that the model was fined. When steaming under the same conditions at 11, 12 and 13 knots (speed ratio 0.55 to 0.65) the average Admiralty coefficient then rose by 5.4 per cent. above the basis model 30*b*, or about one-half of the percentage by which the model was made finer, and it was not until the speed of model 30*b* had been increased to 14 and 14½ knots (speed ratio 0.70 to 0.725) that the increase in the Admiralty coefficient was very pronounced, the average having risen to 17 per cent. above model 30*b*. When the basis model was filled out 9.3 per cent. and displacement increased by 934 tons, the effect on the coefficient was very apparent, it being reduced by a greater degree than had been gained by fining the model.

It is not intended that the standard block shall be unalterable; it is subject to amendment according to the exigencies of the case—but when any deviation occurs the percentage of relative fineness will of course be attended to, as illustrated in Tables A and B. It may be of interest to observe here that the block of the famous Mauretania was the same as the standard block herein referred to, when steaming at full speed on her 48 hours trial.

* See ENGINEERING, vol. xcvii, pp. 463, 465.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several foreign engineering projects, taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Department, 73, Basinghall-street, London, E.C. 2.

Morocco.—H.M. Agent and Consul-General at Tangier (Mr. H. E. White, C.M.G.) reports, under date April 18, that according to the local press a consortium, comprising the French companies and firms of Schneider (Creuzot), Pavillier, Giros and Loucheur, Compagnie Marocaine, Compagnie Générale, and the P.L.M. and Orléans Railway Companies, has been formed to exploit the water power of Morocco. The consortium, it is stated, proposes in the first place to utilise the falls of the Oum-er-Rebia River and probably later the river heads in the Atlas Mountains.

Spain.—With reference to the notice on page 35 of *The Board of Trade Journal* of April 5, relative to a projected underground electric railway system in Madrid, H.M. Consul at that city (Mr. A. Jackson) reports that the contract for the construction of the earth and masonry works of the line No. 1 of the Metropolitan Railway in Madrid has been awarded by the concessionaires of the railway to a Spanish firm, whose name may be obtained on application to the Department of Commercial Intelligence, as above. In making application the reference number (190) should be quoted.

SKIN-EFFECT RESISTANCE AT 100,000 CYCLES.—Continuing their experiments on "Skin-Effect Resistance Measurements at Radio-frequencies up to 100,000 Cycles per Second" (Bulletin 13, Massachusetts Institute of Technology), Messrs. A. E. Kennelly and H. A. Affel confirm the formula of Heaviside-Kelvin, a Bessel function, for the skin-effect, which is defined as the ratio of the alternating-current to the direct-current resistance, for frequencies from 5,000 cycles to 100,000 cycles per second. The conductors were tested in loops of two parallel wires or strips. Some of the results are curious. Thus a strand of seven bare copper wires, all in contact with one another and not twisted, gave the same ratio as one equivalent round wire; but when the wires were twisted the ratio increased, whilst it decreased when the wires were separated and insulated by cotton, enamel, &c. In strips the edge-effect has, further, to be considered, *i.e.*, the tendency of the current to concentrate near the edges at the expense of the current in the central portion; the two effects are akin to one another; the edge-effect formulæ are due to Lord Rayleigh. Slitting a strip parallel to its length did not seem to affect the resistance ratio. Increasing the width of a strip increased the edge-effect; but when a wire is rolled down to a strip, the skin-effect is first diminished, until the edge-effect predominates, reducing the skin-effect; thus there is—as was known, we believe, though not demonstrated for very high frequencies—a certain most favourable strip thickness with respect to the resistance at a given frequency. The edge-effect is reduced when two strips are separated by paper. A strip rolled up to form a tube has a smaller resistance ratio than before, and very small skin-effects can be secured by using such tubes of very small thickness if only mechanically strong enough. A braiding or texture of fine copper wire, placed over a non-conducting core, has a very small skin-effect.

TURIN A SEAPORT.—A most interesting discussion took place a few days ago in the town council of Turin on the motion of Signor Depanis on the proposal to connect the Italian lakes with the Gulf of Genoa by a canal navigable for sea-going vessels. Signor Depanis pointed out that what was hitherto regarded as Utopian had now become admittedly practicable; indeed, the want of internal navigation had been severely felt during the war, railway transport being quite insufficient. Formerly the cost had been looked upon as prohibitive, but it was now seen that the millions would have been well spent and would long since have been recouped by savings. He hoped that the error which took place in regard to railway projects would not be reproduced, and that a number of competing schemes would not be seen opposing one another and preventing anything being done. It was proposed to have three sections of canal—Turin to the sea, Turin to Lago Maggiore, and Turin to Milan, to connect with the canal from thence to the Adriatic. For the second and third agreements would be easy, but certain doubts must be cleared up as regards the first. Some people thought that Genoa should be the outlet; others preferred Savona, and it certainly was the natural port for goods of low value to and from Turin and Piedmont. Vado would be even better for these needs. Genoa was already overburdened. It therefore would not suffer, but, on the contrary, it would be to its advantage to be relieved from serving Piedmont. A committee would require to be appointed to conciliate the various interests. The matter was urgent, and an immediate decision was desirable. The war had not prevented the project of a canal from Milan to the Adriatic being carried out. Why should it delay this equally desirable scheme? After a long discussion the council unanimously resolved, seeing that the canal from Milan to Venice, thanks to the courageous initiative of the city of Milan, is on the point of becoming an accomplished fact, and that a system of canals traversing regions eminently agricultural and industrial and uniting the Gulf of Genoa, the Adriatic and the Lago Maggiore, would be of supreme national interest, that instructions be given to proceed as rapidly as possible with the preparation of a definite scheme for a canal for sea-going traffic from Savona or Vado to the Lago Maggiore via Turin.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

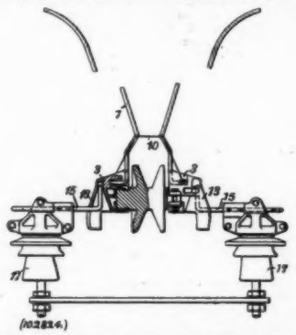
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

102,824. A. Schaanning, Manchester, and S. A. Stigant, Chorlton-cum-Hardy. Fuses. (2 *Figs.*) January 6, 1916.—This invention relates to fuses known as horn-type fuses. According to the invention, the fuse comprises a central part formed of insulating material, preferably porcelain, to the ends of which are attached by suitable clips metal pieces 3, on which the converging-diverging arcing horns 7 are mounted. The fuse wire 10 is also attached to said metal pieces, being wound round the arcing horns at the narrowest part of the gap between them. The metal end pieces are provided with hollow conical parts 13 by which the entire device is supported on the upstanding parts of two L-shaped rods 15 forming the terminals of the circuit to be protected, said rods being carried by insulators



17. The hollow conical portions 13 are provided with downward extensions forming V-shaped notches, which engage with the horizontal parts of the supporting rods 15 so as to guide the device while it is being placed in position. When it is desired to replace a broken fuse, the entire device is removed from the supporting rods 15 so that the fuse may be replaced at leisure and without danger of shock. Another advantage is that an isolating switch, for disconnecting the device from the line, is not required. For the removal and subsequent replacement of the device an insulating pole of wood or other suitable material with a spring clip, the jaws of which are adapted to engage the central part, may be employed, so that it is unnecessary to touch the fuse device or even to approach near to it. (*Sealed.*)

102,845. The M-L Magneto Syndicate, Limited, and E. A. Watson, Coventry. Dynamo-Electric Machines. (3 *Figs.*) February 15, 1916.—This invention relates to dynamo-electric machines of the type in which there are combined with the generator field-winding an additional winding serving as the secondary of a high-tension ignition system and a contact mechanism rotating synchronously with the engine for intermittently making and breaking the circuit of the field-winding.

Fig. 1.

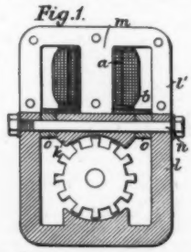
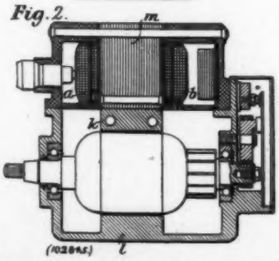


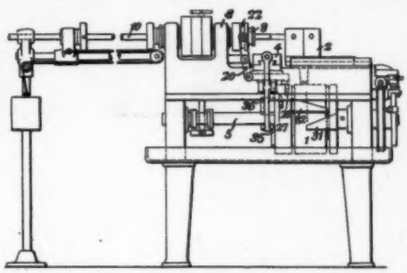
Fig. 2.



The invention comprises the provision in the machine of a magnetic shunt or leakage circuit common to the flux of the wound pole and the opposing flux associated with the armature. The ordinary field-winding *a* is surrounded by another winding *b*, which serves as the secondary of a high-tension ignition system. To avoid excessive interference with the sparking by that magneto-motive force of the armature which opposes the magneto-motive force of the field-winding, a magnetic shunt or leak is provided between each side of the pole-piece *k* and the adjacent side of the yoke or frame *l*. This ensures sufficent flux under all conditions in the core *m* of the field-winding to produce effective sparking when the field-winding is interrupted. The flux due to the opposing magneto-motive force of the armature may then assist in the production of the spark, in that it augments the flux change in the core *m* when the field-winding is interrupted. In the arrangement shown the core *m* is laminated and formed integrally with a laminated portion *l1* of the frame. This portion is removable, and is attached to the main portion *l* in any convenient manner. The pole-piece *k* is secured to the main portion of the frame by cross-bolts *n*, and the leakage paths are filled with blocks *o* of non-magnetic material such as brass, these also being secured by the bolts *n*. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

102,875. F. H. Bedford, Loughborough. Lathes. (7 *Figs.*) May 8, 1916.—This invention relates to automatic lathes of the turret type. According to the chief feature of the invention, a single cam-drum 1 is adapted to open and close the chuck 3, drive the turret 2 forward or backward to or from the work to be operated upon, and move a cross-slide 4 for forming and parting off the work, which is fed through the chuck by a gravity-controlled feed device. The cam-drum 1 is mounted upon a shaft 5. The headstock 8 is provided with the usual



hollow spindle, through which a bar 10 may be continuously fed. The chuck 3 is opened and closed by means of a lever 20, one end of which is disposed in a circumferential groove on the chuck 3 to open or close the jaws when the said sleeve is moved longitudinally. The other end of the lever 20 is actuated through a connecting link by cams 26, 27, arranged on the cam-drum 1. The turret 2 is moved to and from the work by means of a depending arm adapted to engage cams 31, 32, on the cam-drum 1. The cross-slide 4 is operated from cams 35, 36, on the cam-drum 1. (*Sealed.*)

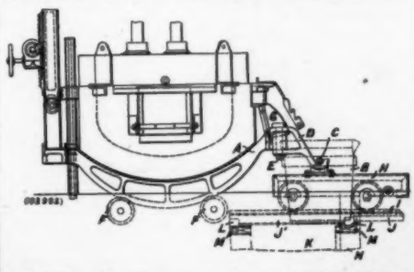
102,911. Vickers, Limited, London, and S. Robinson, Sheffield. Boring Tools. (13 *Figs.*) September 21, 1916.—This invention relates to boring tools. According to the invention, the boring bar is provided with a tool box or holder B, C, made in parts or sections which are telescopically arranged and capable of successive or simultaneous movement in order to advance or retract the cutter or cutters relatively to the work. The said sections are preferably two in number, one (hereinafter termed the inner section C) carrying the cutter or cutters and fitting telescopically in the other (hereinafter termed the outer section B), which is telescopically mounted within a lateral recess in the boring bar A. Any appropriate means may be employed for imparting the telescopic movement to the outer and inner sections; for example, the inner section may be actuated by a rack-and-pinion device F, G, and the outer section by a cam device N. The rack-and-pinion device may comprise an internal

Fig. 1. *Fig. 2.*

rack F on the inner section and a pinion G carried at the extremity of a rod adapted to be inserted in place from one end of the boring bar and engage the said rack. The cam device N may comprise a cam eccentrically mounted on the extremity of a rod adapted to be inserted in place from the opposite end of the boring bar and to extend through a slot in the side of the outer section and engage the under face of the inner section. In an alternative arrangement, which may be employed in cases where it is not feasible to insert independent rods from either end of the bar, as in the case where the shaft to be bored is only hollow for part of its length, the tool box may be situated at or near one extremity of a hollow boring bar, and a single rotable rod may be employed adapted to be inserted into the boring bar from its opposite end and to engage a pair of racks formed respectively in the contiguous sides of both the inner and outer telescopic sections. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

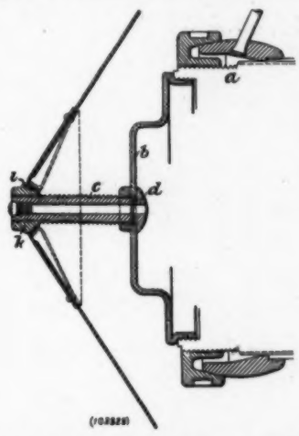
102,902. D. F. Campbell, London, and Société Electro-Metallurgique Francaise, Froges, France. Tilting or Rolling Furnaces. (2 *Figs.*) August 9, 1916.—The invention relates



to tilting or rolling furnaces. In the usual practice during the teeming process the ladle is swung under the spout of the furnace by means of a crane, by which also it is afterwards transferred to the mould or the like into which the liquid is to be poured. According to the present invention, this crane is dispensed with, and the ladle B, placed on a carriage H, is run underneath the lip of the furnace and, during the process of teeming, is temporarily supported on arms projecting from the furnace bed. A is the bed of the furnace, B the ladle; on each side of the ladle is a pin C, which can be engaged by an arm D carrying a vertical bolt E, fitting in a bearing formed in a projection of the furnace bed. The arms D can be swung inwards or outwards about the axis of the bolts E. Means, not shown, are provided for tilting the furnace in well-known manner on the supporting rollers F. The lip of the furnace is shown at G. The ladle B rests, when not attached to the furnace bed, on a carriage H, which can be run to and fro on rails I. In order that the ladle can be lowered into the ladle-pit K when the furnace contents are being transferred to the ladle, fixed girders J, carrying the rails I, are replaced over the mouth of the pit by removable girders J1 and rails I1. In the example shown the removable girders J1 are supported when in position by iron castings L resting on and extending over the sides of padstones M provided on the top of brick pillars N. The lower flanges of the girders J1 are cut away at the ends to allow the webs to enter slots formed in the castings L. When the furnace is to be tilted, the removable girder being in position, the carriage and ladle are run over the rails to the furnace bed, the arms D are swung inwards to engage with the pins C, and the furnace slightly tilted to take the weight of the ladle. The carriage H is run clear of the mouth of the pit and the girders J1 removed. When the molten material has been transferred to the ladle, the furnace is tilted back, the removable girders replaced, and the carriage again brought into the position to receive the ladle, which is lowered on to the carriage and the arms D swung outwards. The carriage and ladle can then be removed. (*Sealed.*)

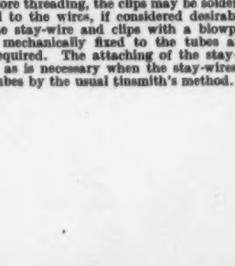
MOTOR ROAD VEHICLES.

102,829. Rudge-Whitworth, Limited, Coventry, and J. V. Pugh, Allesley. Wheels. (2 *Figs.*) January 8, 1916.—This invention relates to vehicle wheels having cover discs. The invention consists in an attachment means for a wheel spoke-covering disc in which access for lubricating the wheel bearings is obtained, without releasing the cover disc, by means of a tubular member passing therethrough. *a* is the outer end of a detachable wheel hub which is fitted with a grease-cap *b* of ordinary type. Co-axial with the grease-cap *b* is a hollow stud *c*, the bore of which communicates with the interior of the hub,



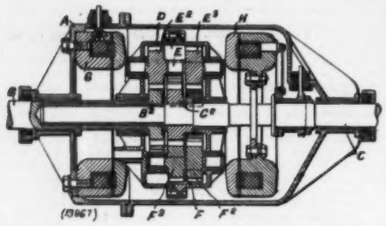
The stud *c* is screw-threaded upon the greater portion of its length, and it is provided with a head *d* and a squared shoulder immediately adjoining the head. The shoulder fits an aperture in the grease-cap *b* by means of a nut engaging the external thread. The outer end of the bore of the stud is provided with an internal screw thread for the reception of a screw for closing the tube. *h* is the spoke-covering disc. The disc *h* is provided with a central aperture *i* having a conical seat, the disc being held in position by a nut *k* screwed upon the thread of the stud *c* and co-operating with the coned seat. (*Sealed.*)

102,880. W. S. Tyler and The Coventry Motor Fittings Company, Limited, Coventry. Radiators. (3 *Figs.*) May 13, 1916.—The tubes of radiators are stayed by one or more wires soldered across the tubes. This construction stiffens up the cooling section and prevents loosening of the tubes where they are attached to the tanks or headers. It is the object of the present invention to provide means whereby soldering of the stay wires is obviated, and accordingly to each tube one or more clips is or are fitted, and through the clips the stay wire or wires is or are threaded. There is fitted to each radiator tube A, a ring B, formed integrally with a projecting tongue C. When



the cooling section is erected, these tongues all lie in the same line, or there may be two or more lines. The tongues are bent over to form hooks as shown, and through the hooks are threaded the stay-wires D. When in position the hooks are pinched together so that each line of hooks clips tightly the stay-wire. By tinning the stay-wires before threading, the clips may be soldered quickly and without skill to the wires, if considered desirable, by just running along the stay-wire and clips with a blowpipe. Thus the stay-wire is mechanically fixed to the tubes and can be removed when required. The attaching of the stay-wires does not require skill, as is necessary when the stay-wires are solely soldered to the tubes by the usual tinsmith's method. (*Sealed.*

13,867/15. G. Pollard and The Menco-Eima Syndicate, Limited, London. Reversing Gearing. (3 *Figs.*) September 29, 1915.—According to the present invention, there is provided in power-transmission systems, the combination with co-axial driving and driven shafts B, C, of a casing or gear wheel carrier A mounted concentrically with them, gearing carried by said casing and shafts coupling them so that the shafts B, C turn in opposite directions at the same speed or approximately so when the casing A is held stationary, an electro-magnetic clutch G to couple the casing A to the driving-shaft B to prevent the gears



from rolling on one another, and a stationary electro-magnetic brake H which alternatively will hold the casing so that the gears will roll on one another. In a preferred construction the gearing comprises a casing D, one or more pairs of countershafts E, F carried by the casing D and parallel to the driving and driven shafts B, C, a gear wheel E^2 on each countershaft of a pair meshing with a gear wheel F^2 on the other, and a second gear wheel E^2, F^1 on each of the countershafts coupled to the first and meshing respectively with gear wheels B^2, C^2, on the driving and driven shafts, &c. (*Sealed.*)

102,820. R. A. Duncan, Adelaide, Australia. Speed Controllers. (2 *Figs.*) January 6, 1916.—This invention relates to control mechanism for preventing excessive speed of motor vehicles, of the type in which a centrifugal governor is mounted upon a shaft which is operated from some part of the automobile which revolves at a speed relative to that of the road wheels, the governor, when a predetermined speed is exceeded, being adapted to disengage an element whereby short-circuiting of the magneto takes place and the transmission of electric current to the sparking mechanism is prevented. In apparatus

Fig. 1.

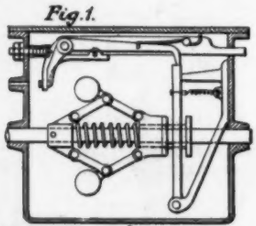
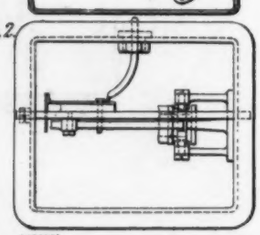


Fig. 2.



according to this invention the circuit-breaker comprises a two-armed lever pivotally mounted upon a shaft, which is capable of axial adjustment to enable the apparatus to operate at various speeds. One arm of the circuit-breaking lever is adapted, after its release by the action of the governor mechanism, to short-circuit the magneto, while the other arm is so arranged, in conjunction with other means, as to be operable from the outside to enable the device to be subsequently reset and the engine restarted. (*Accepted January* 10, 1917.)

PUMPS.

102,842. H. A. Humphrey, London, and W. J. Rusdell, Wolverhampton. Internal Combustion Pumps. (7 *Figs.*) January 26, 1916.—The improvement in the method of ignition in liquid-piston internal combustion engines, pumps or compressors by means of combustible mixture compressed by an inward stroke of the liquid piston and ignited in a chamber separate from the main combustion chamber consists in closing communication between the two chambers during a part or parts of the cycle when such communication might imperil the next ignition. 1 is the ignition chamber communicating by passage 2 with the combustion chamber 3, the communication being controlled by valve 4. The valve 4 is operated by link 10, arm 11, rod 12, arm 13, springs 15 and 16, and ring 14, part of which is alone shown. Each of the springs 15, 16 is attached at one end to the ring 14 and at the other end to the arm 13. The apparatus operates as follows:—The pump, of which 3 is the combustion chamber, is assumed to work on the four-stroke cycle, and pressure rises in the combustion chamber on compression and ignition of the combustible charge therein and again upon compression of the elastic cushion in the combustion chamber immediately following the expulsion of the burnt products, and between such rises in pressure there is an outward and inward stroke of the water column. When splashing occurs in the combustion chamber it is usually greatest on the compression of the elastic cushion, and also shortly after the ignition of the combustible charge. The ring 14, which extends axially round the combustion chamber, operates the admission and exhaust valves of the pump, moving in the direction of the arrow when the pressure rises on compression of the elastic cushion, and in the opposite direction on the ignition of the combustible charge. The device for causing the ring so to move is part of the ordinary mechanism of the pump, and is not shown. Assuming that the elastic cushion is just being compressed, the ring 14 moves in the direction indicated by the arrow. This movement increases the tension on spring 15, thus tending to rotate arm 13 counter-clockwise in *Fig.* 2. The increased tension of spring 15 tends to cause link 10 to move to the left so as to open communication between ignition chamber 1 and combustion chamber 3 by moving valve 4 to the left. Whilst the elastic cushion is compressed, however, the pressure in combustion chamber 3 is exerted against valve 4, thus keeping the valve upon its seat in spite of the tendency of spring 15 to open the valve. It is at this time that splashing is greatest, but the liquid spray is prevented from entering chamber 1 by valve 4. The subsequent expansion of the elastic cushion causes the water column of the pump to move outwardly, and the pressure in the combustion chamber thereupon falls, and so soon as the pressure in the combustion chamber 3 is sufficiently low its action on valve 4 is overcome by the tension of spring 15, which thus causes valve 4 to open. The continued outward movement of the water column causes a reduction of the pressure in the combustion chamber 3, and this is utilised to draw a fresh combustible charge into the chamber 3, and also to draw a supply of carburetted air from the carburettor into the ignition chamber 1, and if desired into passage 2. During the charging stroke there is no tendency to splashing, and the ignition chamber 1 will remain dry. The water column having by its outward stroke drawn a combustible charge into chamber 3, moves inwardly so as to compress this charge. The pressure in chamber 3, passage 2 and chamber 1 again rises, and at the desired moment an electric discharge is produced by known

Fig. 1.

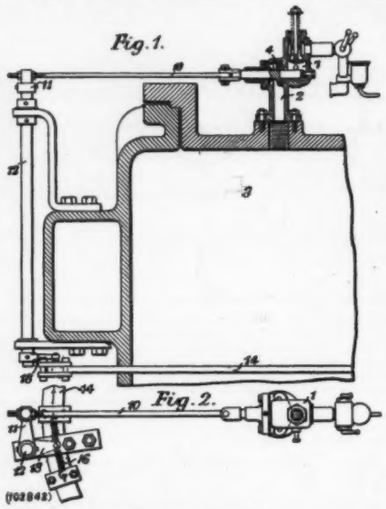
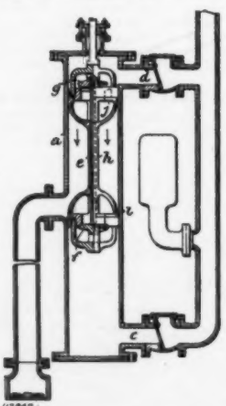


Fig. 2.

means at the sparking plug 20, thus igniting the combustible contents of chamber 1 and, in turn, the charge in chamber 3. The rise of pressure either upon compression, or, later, upon ignition of the combustible charge in chamber 3, causes ring 14 to move in the opposite direction to that indicated by the arrow, thus increasing the tension of spring 16 and decreasing that of spring 15; the effect is to urge valve 4 to the right. It is not usually desirable, however, that the valve shall move until after ignition, and one method of ensuring this is to adjust the device which moves ring 14 so that the movement does not occur until the pressure rises above that chosen for ignition; another method is to use a suitably weak spring 16, so that the pressure in chamber 3 acting upon valve 4, and tending to keep it to the left, is greater than the pressure exerted by spring 16 until the pressure in chamber 3 falls sufficiently during expanson. With the first alternative the valve 4 may close immediately after ignition owing to the ring 14 moving, and the tension of the spring 16 closing the valve; while in the second alternative the valve 4 will close a little later and during the expansion of the ignited gases in chamber 3. In both cases the valve 4 will be closed, thus isolating chamber 1 from chamber 3 during the latter part of the out-stroke of the water column and during the following in-stroke, which expels the products of combustion and compresses the elastic cushion as previously described. It is found that there is little tendency to splash into the ignition chamber 1 during the interval between ignition and the closing of valve 4. (*Sealed.*)

17,042/15. W. J. Grimshaw, Littlehampton, and A. P. Symonds, London. Pumps. (1 *Fig.*) December 3, 1915.—According to this invention, the improved pump is of the kind



wherein two pistons or plungers are connected together to work within a cylinder or barrel having a centrally-disposed induction opening, and wherein each piston is fitted with a valve which opens and closes alternately according to the direction of movement of the piston, and comprises a pump barrel *a* within which is fitted a pair of buckets or pistons *i*, *j*, each having a valve *f*, *g*, adapted to open outwardly, the movement of the leading or forward bucket serving to close its valve and simultaneously open the valve in the other bucket. The two buckets *i*, *j*, are connected to each other by a rod *h* in such a manner that they deliver the water or liquid to delivery outlets *c*, *d*, at either end of the stroke, whilst the valves *f*, *g*, which are situated on the outer sides of the buckets, are mounted at the extremities of a spindle *e* extending from one bucket to the other. (*Accepted January* 10, 1917.)

TEXTILE MACHINERY.

102,817. J. Edmundson, Accrington. Dobbies. (6 *Figs.*) January 5, 1916.—This invention relates to loom dobbies for weaving fabrics having coloured or pattern borders, in which the direction of rotation of the pattern barrel is periodically reversed. The invention provides automatic means for effecting this reversal without the necessity of employing an additonal chain. According to this invention, the usual pattern chain and pattern barrel are automatically reversed by the action of the pattern chain on certain of the jack levers 3, 4, which jack levers rock a shaft or bar 6 controlling the driving pawls 13, 17. The rocking

Fig. 1

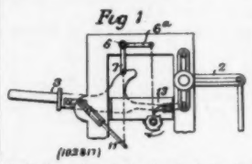
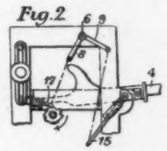


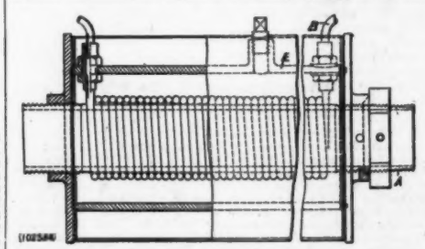
Fig. 2.



shaft 6 carries at the front of the loom a pair of fingers 6a, 7, and at the back of the loom a similar pair of fingers 8, 9, set at an angle to the first pair. The finger 7 is connected to a lever 11 connected to a bracket on the jack lever 3, and the finger 6a is connected to the pawl 13 vibrated by the operating lever 2. The finger 9 is similarly connected to a lever 15 connected to a bracket on the jack lever 4, whilst the finger 8 is connected to a pawl 17 also actuated by the operating lever. The lifting of a jack lever causes the lowering into action of the driving pawl at that side of the dobby, and (through the rocking shaft) the lifting out of action of the pawl at the opposite side of the dobby. (*Sealed.*)

MISCELLANEOUS.

102,388. W. A. Hall, London. Vaporising Oils. (3 *Figs.*) January 6, 1916.—The present invention relates to means for treating liquid fuel, such as paraffin oil, to adapt the same for use in high-speed internal automobile combustion engines. In accordance with this invention, a portion of the fuel



supply-pipe B is arranged as a coil surrounding the exhaust pipe A of the engine, and this portion is housed in a chamber E adapted to be packed with a fusible salt or alloy having a high specific heat; the latent heat of liquefaction is thus utilised as a medium of heat accumulation and distribution. (*Sealed.*)

BY-PRODUCT COKE AND COKING OPERATIONS.—From an instructive article by Messrs. C. J. Ramsburg and F. W. Sperr, of the H. Koppers Company, Pittsburg, published in the Journal of the Franklin Institute of April, 1917, we see that by January, 1915, there were 6,438 by-product recovery ovens in the United States and Canada, of an aggregate capacity to carbonise about 24,000,000 tons of coal and to produce nearly 19,000,000 tons of coke therefrom per annum. Although 500 of these ovens have been discarded, 9,900 ovens are expected to be working by 1918. The increase is ascribed not so much to the inflated war prices of by-products as to the general financial conditions favouring development of plant.

ULTRAVIOLET SPECTRA OF THE HEAVY METALS.—In presenting a communication to the Röntgen Society Mr. C. A. Schunck exhibited beautiful photographs of the ultraviolet spectra of tungsten, molybdenum and uranium, obtained with the aid of a quartz spectrograph made by Messrs. Bellingham and Stanley, and electrodes of the metals or of cored electrodes containing the powdered metal or alloys, or of impregnated carbons. Tungsten forms a spectrum so rich in lines that it looks almost like a continuous band. Metallic tungsten gives the best and most uniform spectra, both in arc and spark; the spectra of cored and impregnated carbons are more intense in the spark. The tungsten spectrum extended down to 2,130 Angström units, the limit of the instrument. Being very rich in ultraviolet rays, these spectra are therapeutically important; eczema, *e.g.*, is treated with ultraviolet rays, but care seems to be advisable there, as in other radiation treatments, though the rays are supposed to be stopped by a thickness of 0.1 mm. of human skin. The iron spectrum is also strong in ultraviolet rays. In the course of his lecture Mr. Schunck gave the following table for the various regions of the spectrum in A.U.:—Visible rays, 7,594 to 3,934; ultraviolet, 3,934 to 1,850; Schumann rays, 1,850 to 1,230; Lyman rays, 1,230 to 600; unexplored, 600 to 11.95 (softest X-rays from sodium, according to Siegbahn and Stentröm) or to 8.36 (aluminium X-ray line).